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Division of Forestry

Forest Health Protection Report

Forest Insect and Disease Conditions in Alaska—1998

ALASKA

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FOREST INSECT AND DISEASE CONDITIONS IN ALASKA — 1998

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General Technical Report R10-TP-74

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CONDITIONS IN BRIEF

Aerial detection mapping is conducted annually to document the location and extent of active forest insect and disease damage. These surveys generally cover approximately 1/3 of the forested land in Alaska. Unlike 1997, when smoke from large wildfires in interior Alaska and inclement weather precluded flights into many areas of concern, conditions cooperated this year, which allowed us to survey in excess of 26 million acres throughout Alaska. Despite declines in spruce beetle activity this year, overall insect activity for the state increased 13%: 1,082,750 acres of damage were recorded. The most important diseases and declines in Alaska are characterized as chronic conditions and remain relatively unchanged from 1997.

INSECTS:

Spruce beetle activity continues to decline, falling by 42% in 1998. Since 1996, when the spruce beetle epidemic peaked at 1.13 million acres, levels fell to 563,000 acres in 1997, then to 316,800 acres in 1998. This acreage is the lowest figure since 1978. Lack of suitable host material within susceptible stands (i.e., stands of mature, even-aged, slow-growing spruce) most likely accounts for this continued decline. It is expected that spruce beetles will remain active in limited areas. In fact, while most areas are in decline, others remain quite active such as the west shore of Cook Inlet. Some areas, such as the Kenai Peninsula from Ninilchik south to Homer, have actually experienced a slight increase in activity.

Total spruce beetle activity in southeast Alaska decreased from 35,700 acres in 1996, 19,050 acres in 1997, to 4,220 acres in 1998, mostly from the Haines area. There was no new beetle activity in Glacier Bay National Park or on the ridge east of Gustavus. The infestation at the mouth of the Stikine River and Taku River has almost completely collapsed.

Spruce needle aphid occurred on 44,300 acres in Southeast Alaska from the southern end of Prince of Wales Island to Cape Fairweather in 1998. Though much of the acreage affected was along the beach fringe on Chichagof and Baranof Islands, Sitka spruce within the Verstovia stand in Sitka were infested to the highest elevation of the spruce-hemlock forest type.

Spruce budworm activity, increased in 1998 by 128% over 1997 levels. An outbreak at Tanana, is largely responsible for this increase which had declined in 1997 by 84% over 1996 levels. Once again, nearly all the intense budworm activity is concentrated along the Yukon River and continues it's westward migration toward Ruby and Galena.

Willow leaf blotchminer, which was at endemic levels in 1997, rose dramatically in 1998 to over 120,000 acres. Most of the blotchminer activity is centered in the upper Yukon and Porcupine River valleys. The 120,000-acre figure should be considered conservative. Most of the muskeg areas along the aerial survey flightlines were affected and it is reasonable to assume that the blotchminer is active throughout much more of this area. However, due to budget and time constraints, we were unable to survey non-timbered areas off the major river drainages.

Defoliation attributed to the **large aspen tortrix** increased by over 300% in 1998. Most of the tortrix activity was concentrated in two areas, namely the central Kenai Peninsula and the vicinity of Northway, along the Alaska Highway and Nabesna River.

Larch sawfly continues to be quite active throughout the range of larch in interior Alaska, resulting in 461,800 acres of defoliation. This is the sixth consecutive year of major larch sawfly activity. In many of the defoliated areas, patches of larch mortality are beginning to appear. The major area of sawfly activity continues to be from the Alaska Range west to the Kuskokwim River.

In southeast Alaska, **Hemlock sawfly** defoliation levels decreased from 8,250 acres in 1996, 6,640 acres in 1997, to 3,920 acres in 1998.

No acres of **Black-headed budworm** were recorded this year. The populations have collapsed in southeast Alaska. In Prince William Sound, where budworm defoliation occurred in 1996 and 1997, adverse flying conditions disallowed a survey of this area.

DISEASES:

The most important diseases and declines of Alaskan forests in 1998 were wood decay of live trees, root disease of white spruce, hemlock dwarf mistletoe, and yellow-cedar decline. Except for yellow-cedar decline, trees affected by these diseases are difficult to detect by aerial surveys. Nonetheless, all are chronic factors that significantly influence the commercial value of the timber resource and alter key ecological processes including forest structure, composition, and succession. Wood decay fungi, hemlock dwarf mistletoe, and spruce broom rust provide important wildlife habitat through the formation of tree cavities and witches' brooms.

In southeast Alaska, approximately one-third of the gross volume of forests is defective due to **stem** and **butt rot fungi**. **Hemlock dwarf mistletoe** continues to cause growth loss, top-kill, and mortality in old-growth forests; its impact in managed stands depends on the abundance of large infected trees remaining on site after harvesting. Approximately 477,000 acres of **yellow-cedar decline** have been mapped across an extensive portion of southeast Alaska. Snags of yellow-cedar accumulate on affected sites and forest composition is substantially altered as yellow-cedar trees die, giving way to other tree species. Salvage opportunities for this valuable resource are now being recognized.

In south-central and interior Alaska, **tomentosus root rot** continues to cause growth loss and mortality of white spruce. Tomentosus root rot is the most important disease of young-growth spruce in the boreal forests. Several heart and butt rot fungi continue to cause substantial decay of mature white spruce. Sap rot decay of spruce bark beetle-killed trees, primarily caused by the **red belt fungus**, continues to rapidly develop and degrade dead spruce trees, particularly those trees with sloughing bark and wood checks. A high incidence of stem decay and root rot, caused by several fungi, occurs in mature birch and aspen stands.

Cone and foliar diseases of conifers were generally at low levels throughout Alaska in 1998. Canker fungi caused substantial, but unmeasured, damage to hardwood species in south-central and interior Alaska.

Other:

In localized areas of southeast Alaska, feeding by porcupines and brown bears continues to cause tree damage to several conifer species.

Table 1. 1998 forest insect and disease activity as detected during aerial surveys in Alaska by land ownership and agent[1]. All values are in acres.

Damage Agent	State & Private	National Forest	Other Federal	Native Corp.	Total 1998	*Difference From 1997*
Larch Sawfly	71,170	0	297,100	93,870	461,780	*+193,919*
Willow defoliation	9,910	290	46,720	46,150	123,070	*+119,569*
Spruce budworm	5,420	0	41,640	30,820	87,800	*+49,384*
Spruce needle aphid	8,650	30,680	4,650	2,300	46,340	*+45,819*
Large aspen tortrix	4,750	-	8,170	8,905	21,830	*+16,747*
Engravers/spruce beetle	1,950	0	8,700	2,535	13,170	*+4,224*
Cottonwood defoliation	3,690	90	720	2,110	6,610	*+3,574*
Yellow-cedar decline[2]	22,015	434,920	323	21,823	479,082	*+1,542*
Willow rust	90	0	450	0	540	*+540*
Landslide damage	20	20	100	80	220	*-229*
Porcupine damage	0	80	0	0	80	*-1,083*
Water damage	300	160	60	320	830	*-1,219*
Blowdown/windthrow	10	50	90	0	150	*-2,075*
Hemlock sawfly	90	3,820	0	10	3,930	*-2,708*
Winter damage	0	0	0	0	0	*-2,948*
Spruce needle rust	0	0	100	0	100	*-10,676*
Black-headed budworm	0	0	0	0	0	*-30,842*
Spruce beetle	178,930	3,470	58,410	75,010	316,800	*-246,941*
Total Acres	**306,995**	**473,580**	**477,233**	**293,933**	**1,562,332**	***+136,597***

[1] Table entries do not include many of the most destructive diseases (e.g., wood decays and dwarf mistletoe) because these losses are not detectable in aerial surveys.

[2] Value of yellow-cedar decline is not restricted to the acreage with a high concentration of dying trees for this year; it represents stands that generally have long-dead trees, recently-dead trees, dying trees, and some healthy trees. See discussion of yellow-cedar decline for a detailed listing of affected acreage by island and Ranger District.

Table 2. Acreage having active insect damage, by year since 1993, and the cumulative area (in thousands of acres) affected for the last 6 years.

Damage Agent	**1993 Total**	**1994 Total**	**1995 Total**	**1996 Total**	**1997 Total**	**1998 Total**	**Cumulative Totals[1]**
Spruce beetle	730.1	610.2	893.9	1,133.0	562.7	316.8	**2,282.0**
Larch sawfly	2.1	0.3	116.9	606.9	267.6	461.8	**1371.5**
Spruce budworm	34.5	232.1	279.3	235.9	38.4	87.8	**602.1**
Black-headed budworm	233.8	188.1	13.0	1.2	30.8	--	**401.2**
Willow defoliation	47.8	12.5	5.6	50.1	3.5	123.1	**229.6**
Large aspen tortrix	117.5	9.2	32.4	6.4	5.1	21.8	**186.6**
Engravers/spruce beetle	4.8	22.5	5.6	13.9	8.8	13.2	**68.8**
Spruce needle aphid	0.2	1.5	0.1	0.5	24.8	46.4	**48.8**
Hemlock sawfly	4.6	3.0	1.1	8.3	6.6	3.9	**27.0**
Cottonwood defoliation	1.0	3.8	3.5	5.4	3.0	6.6	**23.8**
Birch defoliation[2]	0.1	--	0.9	3.2	5.4	0.1	**9.7**
Total Acres	**1,1774**	**1,083.0**	**1,352.2**	**2,064.9**	**956.7**	**1,081.5**	**5,251.1**

Highlight maps representing current and/or cumulative damage for spruce beetle, spruce needle aphid can be found in the appropriate sections.

[1] The same stand can have active infestation for several years. The cumulative total is a union of all areas for 1993 through 1998.

[2] The acreage of birch defoliation was improperly reported in the 1997 report, as 271.9 thousands of acres. The correct value is 5.4 thousands of acres for 1997.

[3] Due to a calculation error in the 1997 Forest Insect and Disease Conditions Report, the acreage totals as well as the individual totals may be different from previously reported values.

THE ROLE OF DISTURBANCE IN ECOSYSTEM MANAGEMENT

One premise of ecosystem management is that native species are adapted to the natural disturbances common to an area. Disturbance events are responsible for the way the current landscape appears and functions, and will determine the structure and composition of future landscapes. In Alaska, glaciation, earthquakes, wind storms, fire, flooding, avalanches and landslides greatly affect ecological processes. These types of disturbances remove existing vegetation and often expose mineral soil for new plants to become established.

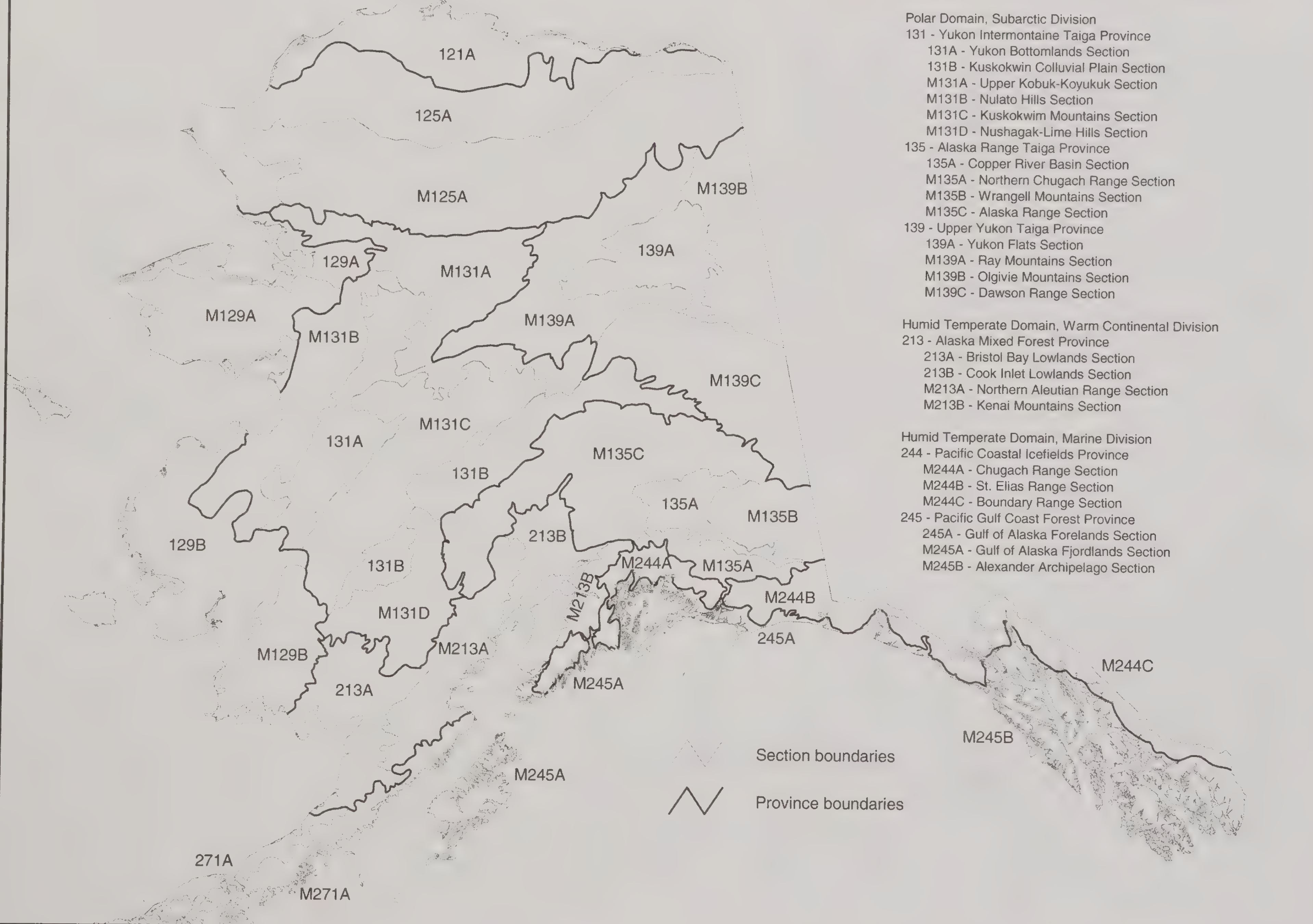
Disturbance events such as insect and disease outbreaks also result in shifting landscape patterns. These disturbances usually affect only a few species directly, while indirectly affecting the remaining species through reduced competition or changes in forest structure. Changes resulting from these types of disturbances often occur over varying time periods, but can be very dramatic and cover large areas. Spruce beetles have radically affected the landscape in a single decade, heartrots and other internal decay fungi operate for decades, whereas yellow-cedar decline has been occurring for nearly 100 years.

To a certain extent, we can predict what type of disturbance is likely to occur in a particular region: fires are frequent in interior Alaska and wind storm events are important in southeast. Spruce beetles are an important disturbance agent in south-central Alaska. Disturbance agents and patterns are generally tied to geography, climate, and vegetation. When we understand the complexities of these relationships, we are able to predict and respond to natural disturbances and mimic the desirable effects with management activities. Ecological classification is one tool available to help us understand disturbance patterns.

Several useful systems of classification have been developed for Alaska's ecosystems and vegetation. Refining and standardizing these classifications across all ownership's will promote effective ecosystem management. ECOMAP (1993) is one system of ecological classification that the Forest Service has adopted and continues to develop. Within this hierarchical system, ecosystems are delineated at multiple scales using different sets of environmental factors. The levels established at this time include Domains, Divisions, Provinces and Sections. Domains represent subcontinental climatic zones. Divisions and Provinces represent climatic subzones as reflected by dominant lifeforms (meadows vs. forests) and broad vegetation types, respectively. Mainly geomorphic and topographic features distinguish sections. The Section level is the first level of the hierarchy where analysis of insect and disease activity becomes applicable.

Through out this report, we make reference to the Ecosystem Sections of Alaska (see the following page). This map was developed in the Alaska Region (Nowacki and Brock 1995). Section descriptions are included in Appendix D with a list of typical damaging agents. Only Sections where forest cover occurs are described. As the ecological hierarchy classification and mapping are developed to finer scales, they become more valuable as management tools to predict the impacts of various disturbances on forest resources.

Ecosystem Sections of Alaska



STATUS OF INSECTS

INSECTS AS AGENTS OF DISTURBANCE

Insects are among the most significant components of Alaska's ecosystems. Arctic/boreal insects are characterized by having few species and large population numbers. These insects are opportunistic in their behavior. They respond quickly to changes in climate and the availability of food and breeding material. The spruce beetle, for example, responds quickly to large scale blowdown, fire-scorched trees, and spruce injured by flooding. Large numbers of beetles can be produced in such breeding material, leading to potential outbreaks.

Spruce beetles are one of the most important disturbance agents in mature white spruce stands in south-central and interior Alaska. A variety of changes occur to forest resources when many trees are killed. Ultimately, these changes are biological or ecological in nature. There are also socio-economic consequences that can be viewed as either positive or negative, depending on the forest resource in question. Some of the impacts associated with spruce beetle infestations include, but are not limited to:

1. Loss of merchantable value of killed trees: The value of spruce as saw timber is reduced within three years of attack in south-central Alaska due to weather checking and sap-rots. The value of a beetle killed trees as house logs, chips, or firewood continues for many years if the beetle-killed tree remains standing.

2. Long term stand conversion: The best regeneration of spruce and birch occurs on a seed bed of bare mineral soil with some organic material. Site disturbances such as fire, windthrow, flooding, or ground scarification provide excellent sites for germination and establishment of seedlings if there is an adequate seed source. However, on some sites in south-central Alaska, grass and other competing vegetation quickly invade the sites where spruce beetles have "opened up" the canopy. This delays re-establishment of tree species.

3. Impacts to wildlife habitat: Wildlife populations, which depend on live, mature spruce stands for habitat requirements may decline. We expect to see decreases in red squirrel, spruce grouse, Townsend Warblers, and possibly Marbled Murrelet populations. On the other hand, wildlife species (moose, small mammals and their predators, etc.) that benefit from early successional vegetation such as willow and aspen may increase as stand composition changes.

4. Impacts to scenic quality: Scenic beauty is an important forest resource. It has been demonstrated that there is a significant decline in public perception of scenic quality where spruce beetle impacted stands adjoin corridors such as National Scenic Byways. Maintaining or enhancing scenic quality necessitates minimizing impacts from spruce beetle infestations. Surveys have also shown that the public is evenly divided as to whether spruce beetle outbreaks damage scenic quality in back-country areas.

5. Fire hazard: There is concern that fire hazard in spruce beetle impacted stands will increase over time. After a spruce beetle outbreak, grass or other fine vegetation ground cover increases; fire spreads rapidly through these vegetation types. As the dead trees break or blow down (5-10 years after an outbreak), large woody debris begins to accumulate on the forest floor. This wood is the heaviest component of the fuels complex. Heavy fuels do not readily ignite, but once ignited they burn at higher temperatures for a longer period. The combination of fine, flashy fuels and abundant large woody debris results in a dangerous fuels situation. Observations from recent fires on the Kenai Peninsula have shown an increase in crown fires. This fire behavior is caused by fire traveling up the dead spruce trees and spotting into the crowns of adjacent beetle killed trees. In some areas, there may be an increase in the lower level winds because of a "reduction" of the wind-break characteristic of a green forest, thus augmenting fire crowning behavior.

6. Impact to fisheries: If salmon spawning streams are bordered by large diameter spruce and these trees are subsequently killed by spruce beetles, there is a concern as to the future availability of large woody debris in the streams. Large woody debris in spawning streams is a necessary component for spawning habitat integrity.

7. Impact to watersheds: Intense bark beetle outbreaks can kill large amounts of forest vegetation. The "removal" of significant portions of the forest will impact to some degree the dynamics of stream flow, timing of peak flow, etc. There have been no hydrologic studies in Alaska quantifying or qualifying impacts associated with spruce beetle outbreaks. Impact studies, however, have been done elsewhere. In Idaho watersheds impacted by the Mountain Pine Beetle, there was a 15% increase in annual water yield, a 2-3 week advance in snowmelt, and a 10-15% increase in low flows.

There are a variety of techniques that can be used to prevent, mitigate, or reduce impacts associated with spruce beetle infestations. However, before pest management options can be developed, the resource objective(s) for a particular stand, watershed, landscape, etc. must be determined. The forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered because population levels will determine the priority of management actions and the type of strategy to be invoked. The key to forest ecosystem management is to manage vegetation patterns in order to maintain species diversity, both plant and animal, while providing for a multitude of resources such as recreation, fisheries, wildlife, and the production of wood fiber. Properly applied silvicultural practices as well as fire management in south-central and interior Alaska, can maintain the forest diversity needed to provide the range of products and amenities available in the natural forest for now and in the future.

Bark Beetles

Spruce Beetle

Dendroctonus rufipennis Kirby

Total acreage affected by spruce beetles declined by 44% in 1998. A depletion of suitable host material (substantial mortality in most stands) along with a cool, wet summer most likely accounted for this substantial decline. Although spruce beetle activity has dropped to near-endemic levels in some areas, it remains quite active in others. Of the 30 areas tracked annually in south-central and interior Alaska for spruce beetle activity, 24 experienced declines and none of the areas which increased, did so substantially. Total spruce beetle activity in south-central and interior Alaska covered 312,450 acres with the vast majority occurring on the Kenai Peninsula and the Cook Inlet basin.

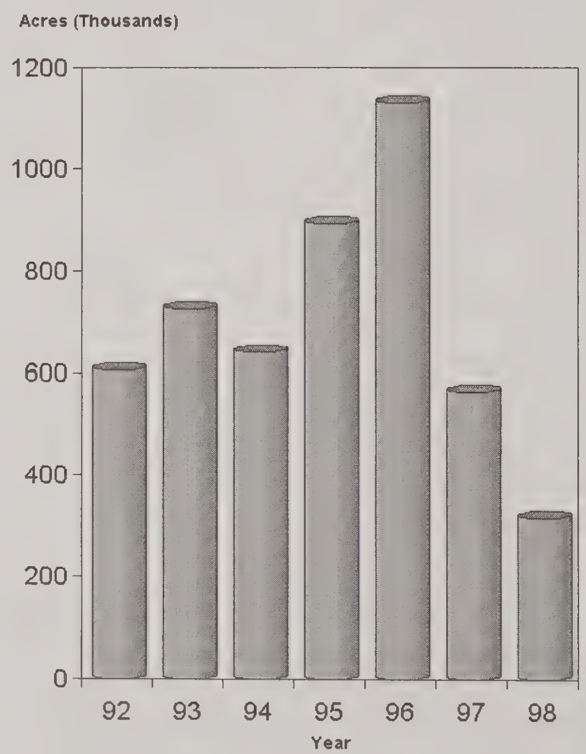


Figure 1. Acres of ongoing and new spruce beetle infestations in Alaska, 1992-1998.

It should be noted, however, that although current levels of infestation have declined, the spruce beetle has impacted 2-3 million acres of forested land over the past ten years. The challenges stemming from past beetle activity, such as fuel-loading, habitat changes, hydrological changes and liability issues remain for forest managers and private landowners alike.

South-central Alaska

Kenai Peninsula

Only 1% of the total spruce beetle activity in 1998 on the **Kenai Peninsula** occurred on the Chugach National Forest. The National Forest experienced a 71% decline from 1997 levels, this year totaling 2,950 acres. This figure represents the third consecutive year of declining numbers. To some extent, this decline in affected acreage can be attributed to the cool, wet weather and subsequent reduction in beetle numbers. The loss of much of the suitable host material to spruce beetles in the past 20 years, however, is probably much more responsible. Continued activity can be expected in limited areas, though large scale activity is unlikely.

In the **Trail Lakes/Moose Pass area** (M213B)*, the number of acres infested by spruce beetle declined from 1996 to 1997; however, there were still areas of activity noted. In the 1997 Conditions Report, these areas of activity were characterized as "areas impacted by beetles 're-entering' a previously heavily impacted stand to infest residual trees". The 69% decline in acres affected, from 5,059 acres in 1997 to 1,557 acres in 1998, indicates that many of the residual trees have now been killed and it is expected that numbers will decline further next year. Parts of this area may yet experience "light" activity for the next several years.

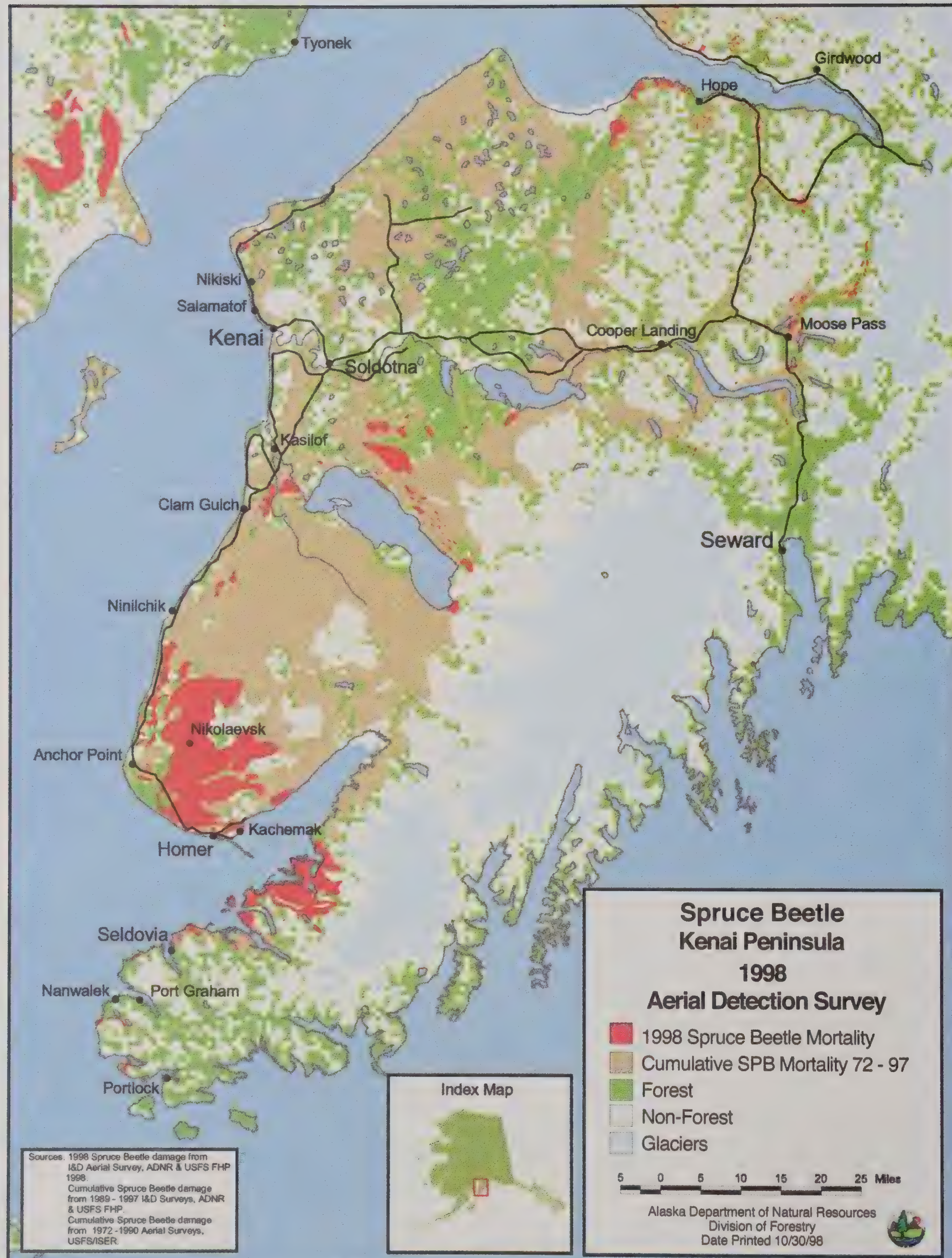
With the exception of all but one area, beetle populations throughout **Turnagain Arm** (M213B) declined. After two years of relatively light (90 acres) beetle activity in the Portage River valley, none was reported in 1998. From Ingram Creek, at the bottom of Turnagain Pass, to the Hope "Y" along the Seward Highway, populations fell for the second consecutive year to only 330 acres in 1998, a 65% decline. The majority of this activity was located between Granite Creek and the Hope "Y". The small population of beetles working in the stands of the Twentymile River valley has nearly disappeared. Number of beetle-impacted acres fell from a high of 775 acres in 1996 to only 25 acres this year. Further activity in the Twentymile valley can be expected if weather conditions are favorable next year. For the second year, declines of 75% were experienced in the Hope, Palmer Creek and Bear Valley area. Only 234 acres were observed this year. The only area of Turnagain Arm where populations were found to be increasing was in the Sixmile Creek valley. This valley has experienced an up and down pattern of activity for the past five years. In 1998, populations rose by 82% to 545 acres. With considerable host material yet available in the valley, further activity may still occur.

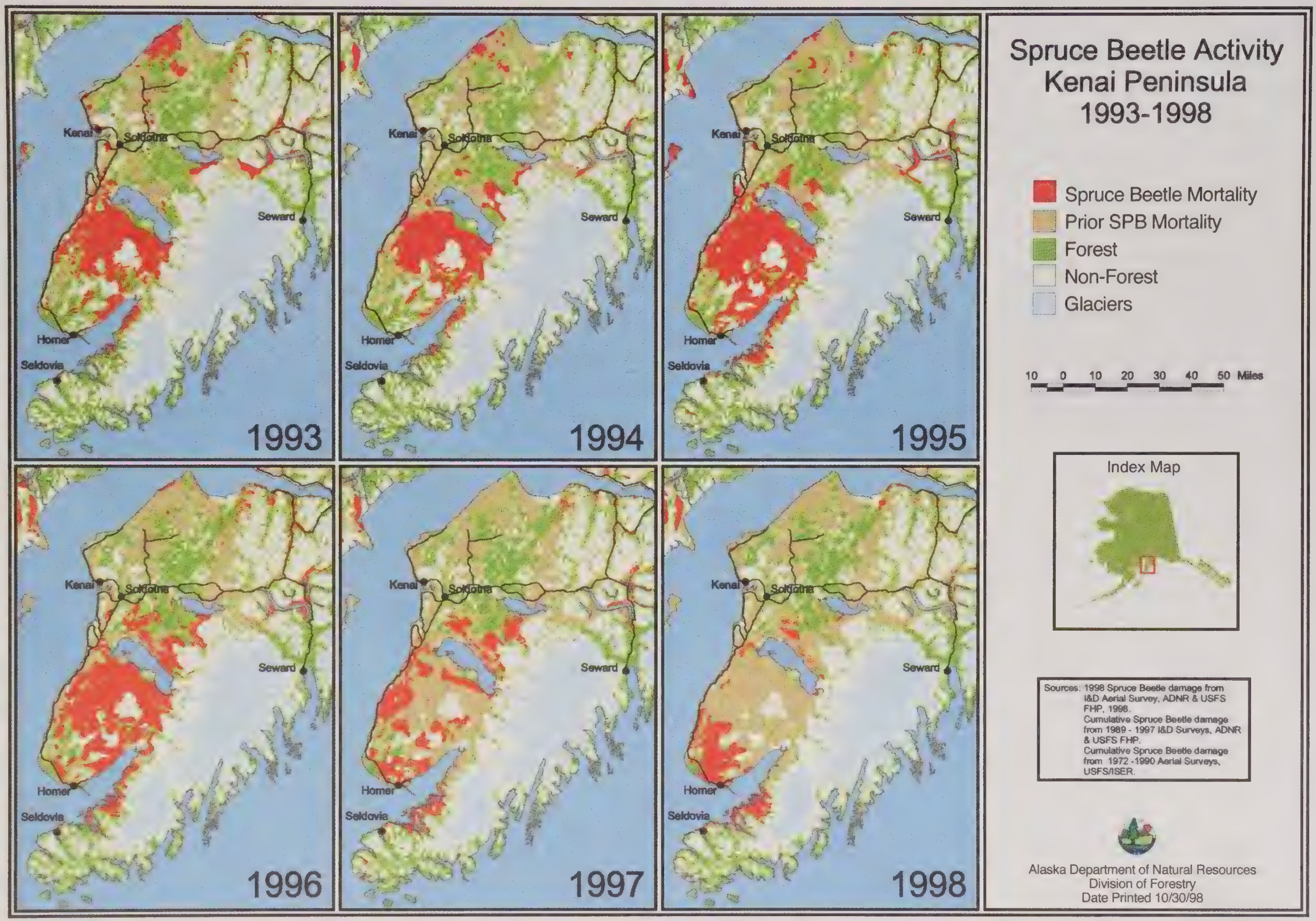
Between **Lawing** and **Seward** (M245A), beetle activity continues at virtually the same level (1,154 ac.) as in 1997. The majority of the activity occurs at Black Mountain where 934 acres of infestations were observed. Light, scattered activity was noted in the Snow River valley but no new activity was found between the Snow River valley and Seward along the Seward Highway. It is expected that in 1999, activity should remain light over much of this area with the possibility of slight declines around Black Mountain.

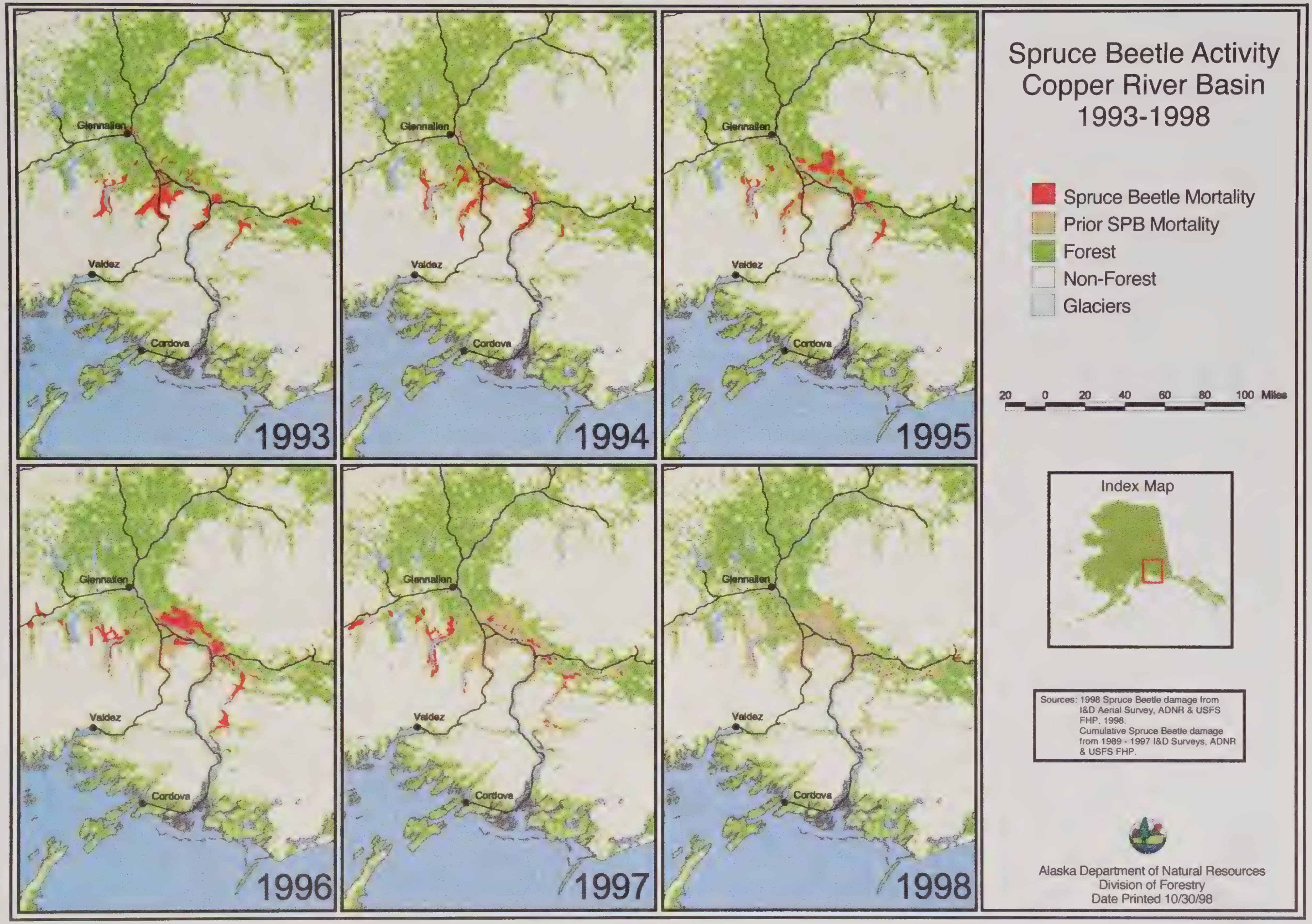
Along the **Resurrection River** between Upper Russian Lake and Seward (M213B, M245A), 310 acres of spruce beetle activity was observed. This area has not been aerially surveyed for several years and it appears that this is an ongoing infestation.

On the **Kenai National Wildlife Refuge**, the acres of observed spruce beetle activity from Pt. Possession to Tustumena Lake declined by 60% in 1998. 19,071 acres of spruce beetle impacted lands were noted. In the Big and Little Indian River drainages (M213B) just east of the Chikaloon River in the northeast corner of the Refuge, 3,970 acres of beetle activity were reported. The balance of the total impacted acres were located between Skilak and Tustumena Lakes (213B). Of note, is the fact that for the first time in more than 30 years, no beetle activity was found between Pt. Possession and Skilak Lake with the exception of that in the Big and Little Indian drainages.

* The number following place names refer to ecosystem section designations. Refer to page 6 and Appendix D.


Spruce Beetle
Kenai Peninsula
1998
Aerial Detection Survey
1998 Spruce Beetle Mortality
Cumulative SPB Mortality 72 - 97
Forest
Non-Forest
Glaciers
5 0 5 10 15 20 25 Miles
Alaska Department of Natural Resources
Division of Forestry
Date Printed 10/30/98
Index Map
Sources. 1998 Spruce Beetle damage from I&D Aerial Survey, ADNR & USFS FHP 1998.
Cumulative Spruce Beetle damage from 1989 - 1997 I&D Surveys, ADNR & USFS FHP.
Cumulative Spruce Beetle damage from 1972 -1990 Aerial Surveys, USFS/ISER.
Tyonek
Girdwood
Hope
Nikiski
Salamatof
Kenai
Soldotna
Cooper Landing
Moose Pass
Kasilof
Clam Gulch
Seward
Ninilchik
Nikolaevsk
Anchor Point
Kachemak
Homer
Seldovia
Nanwalek
Port Graham
Portlock


Spruce Beetle Activity
Kenai Peninsula
1993-1998
Spruce Beetle Mortality
Prior SPB Mortality
Forest
Non-Forest
Glaciers
10 0 10 20 30 40 50 Miles
Index Map
Sources: 1998 Spruce Beetle damage from I&D Aerial Survey, ADNR & USFS FHP, 1998.
Cumulative Spruce Beetle damage from 1989 - 1997 I&D Surveys, ADNR & USFS FHP.
Cumulative Spruce Beetle damage from 1972 -1990 Aerial Surveys, USFS/ISER.
Alaska Department of Natural Resources
Division of Forestry
Date Printed 10/30/98
Kenai
Soldotna
Seward
Homer
Seldovia
1993
1994
1995
1996
1997
1998


Spruce Beetle Activity
Copper River Basin
1993-1998
Spruce Beetle Mortality
Prior SPB Mortality
Forest
Non-Forest
Glaciers
20 0 20 40 60 80 100 Miles
Index Map
Sources: 1998 Spruce Beetle damage from I&D Aerial Survey, ADNR & USFS FHP, 1998.
Cumulative Spruce Beetle damage from 1989 - 1997 I&D Surveys, ADNR & USFS FHP.
Alaska Department of Natural Resources
Division of Forestry
Date Printed 10/30/98
Glennallen
Valdez
Cordova
1993
1994
1995
1996
1997
1998

In one of the few areas of rising population numbers, beetle activity increased between **Homer** and **Ninilchik** (213B) by 8% to 99,263 acres in 1998. This rise is consistent with the 1997 prediction of increasing populations; however, with so many years of heavy activity in this area, depletion of suitable host material may soon reverse this trend. This has been the case in other areas of the southern Kenai Peninsula such as Caribou Hills, Fox River valley, Bradley Lake and Sheep Creek, where no new beetle activity was noted for the first time in years.

The **Kachemak Bay** (M245A) portion of the Kenai Peninsula experienced a slight rise in numbers of beetle-impacted acres. 29,351 acres of spruce beetle activity were noted this year and represents a 7% increase over 1997 levels. While all of the beetle activity in the eastern portion of the Bay has ceased, it has been replaced by expansion of beetle activity into new areas of the western part of the Bay. Although China Poot Bay remains the site of the most intense activity, new activity along with intensification of old activity between Sadie Cove and Port Graham accounts for the increase of beetle-impacted acres. It is likely this pattern of declining populations in the eastern portion of the Bay with increasing populations in the western portion of the Bay will persist for several years as long as suitable host material and weather patterns conducive to beetle flight and development exist.

On the whole, active spruce beetle infestations on the Kenai Peninsula have declined by 56% from 1997 levels of 274,821 acres to 120,476 acres in 1998.

Cook Inlet

On the west side of **Cook Inlet**, spruce beetle activity persists at a fairly high level. 33,943 acres of activity were observed in 1997. This figure, however, is misleading. Inclement flying weather with extremely low visibility limited observation of much of this area in 1997. It is now believed that the 1997 figure was probably much closer to the 1996 reported figure of 85,232 acres. Using the 1996 figure as a base for comparison, this area experienced a 6% decline in 1998. 80,179 acres were reported in 1998.

The **Tuxedni Bay** (213B) infestation has run it's course. Crescent Lake and River, just east of Tuxedni Bay, are the areas of most intense activity on the west side of the Inlet. Nearly 100% of the susceptible spruce, 36,197 acres, are under attack in this drainage. In Redoubt Bay, beetle activity fell to only 701 acres in 1998, a 95% decline over 1997 levels. The spruce stands in this bay are sparse and scattered and as a result, much of the suitable host material has been depleted. Beetle activity in Redoubt Bay should remain static or begin to decline in the next few years. In the West Forelands, beetle activity increased by 10% in 1998, as predicted in 1997.

The **Iliamna Lake** (M213A) outbreak declined by 68% to 18,838 acres. Beetle activity in this area should continue to decline over the next several years. To the west of the main outbreak area, spruce thins out as the habitat changes to tundra. There is not enough host material to support a continuation of beetle activity. There was some concern that the beetles from Iliamna Lake would move east onto the Iniskin Peninsula where 311 acres were observed in 1997; however, no beetle activity was found on the peninsula in 1998.

Anchorage & Mat-su Valley (213B)

Following three years of increasing beetle populations between 1994 and 1996, number of beetle-impacted acres fell for the second consecutive year in 1998. A total of 5,405 acres of activity was noted this year, a 53% decline over 1997 levels. Spruce beetles have already killed most of the susceptible host material in such areas as Fire Island, Kincaid Park, the upper hillside and Potter Creek. Most areas of activity are characterized as experiencing light to moderate infestations with the exception of the upper Ship Creek valley where the activity is heavy. Nevertheless, activity in this valley fell 66% to 2,485 acres. Other areas of decline include the Eagle River valley at 856 acres, down 83%, Eklutna River valley at 311 acres, down 93% and the Knik River valley at 2,179 acres, down 66%. These trends should continue in the next few years. Populations also fell on Fort Richardson and Elmendorf Air Force Base. Just over 500 acres of beetle activity were noted during 1998 survey flights.

Beetle activity in the **Susitna River** valley continues at its characteristic low but persistent level; 818 acres of light activity were noted. This trend is expected to continue in the valley where mixed stands of spruce and hardwoods limit the spread of the beetle.

Figure 2. Spruce mortality on the south side of Kachemak Bay, resulting from a spruce beetle outbreak 12 years ago.

Figure 3. Recent spruce beetle caused mortality near Homer.

Figure 4. Bark beetle galleries.

Glenn Highway
North and east along the Glenn Highway from **Palmer** to **Eureka** (213B, M213B, M135A, 135A), beetle activity declined by 70% to 8,416 acres. The number of infested acres should continue to decline over the next several years as this area has already been heavily impacted.

Within the area bounded by Tazlina Lake and the Glenn Highway, from **Eureka** to **Glennallen** (135A), acres of beetle activity fell 97% to only 384 acres. This area is at treeline and is characterized by widely scattered spruce. Nearly 100% of the susceptible spruce has been killed and therefore it is safe to assume beetle activity in this area is over.

Specifically, in the **Tazlina/Kiana Lakes** area, beetle activity declined by 94% to 467 acres. Small pockets of activity are ongoing; however, much of the area has already been impacted and beetle activity is expected to continue decreasing.

Finally, in the **Klutina/St. Anne Lakes** area, beetle activity declined 97% to 1,012 acres. The outbreak here is essentially over as well.

Copper River Basin (135A)
In the mid-Copper River Valley, from **Copper Center to Chitina**, beetle activity (4,437 ac.) continues to decline, an 85% decline over 1997 levels. Nearly all the beetle activity is located along the Copper River. No new activity was noted between the Copper River and the Wrangell Mountains where widespread, heavy activity occurred for a number of years.

East along the **Chitina River to McCarthy**, beetle activity fell by 10% to 7,045 acres. The heaviest activity is in the vicinity of Kennicot Glacier where 2,724 acres of beetle activity continues. The remaining acres are spread out over the much larger area.

Interior Alaska

Poor flying weather with low visibility precluded flights into the **Kuskokwim River area**, from McGrath, south to Stony River (M131C). This is the second consecutive year this area was not surveyed. In 1996, 3,522 acres of beetle activity was observed. There are large stands of mature spruce in this area and the potential for expansion of activity is high. The only other region in interior Alaska with spruce beetle activity of note is along the **Yukon River** between **Bullfrog Island** and **Nulato** (M131B). In this area, 14,479 acres of spruce beetle-impacted stands were observed. Tree mortality along the river is a result of not only spruce beetle, but *Ips* species as well. Beetle activity in this area should persist, as there are large volumes of host material remaining.

Southeast Alaska

Spruce beetle activity in southeast Alaska's Sitka spruce forests declined by 45% to 19,000 acres in 1997, and 10% to 4,400 acres in 1998 from 1996 infested acres. Most of the 1998 acres (77%) were in the Haines area. There were only 90 acres on the Chatham, 40 acres on the Stikine, and 850 acres on the Ketchikan Areas of the Tongass National Forest.

The **Haines** area (M244C) has experienced the most substantial spruce beetle pressure in southeast Alaska. There were 3,190 acres recorded along drainages of the Chilkat, Klehini and Kelsall Rivers in 1998 compared to 12,300 in 1997, and 13,800 acres in 1996. The majority of this area is located on state lands. State personnel have increased salvage efforts in the Haines area.

Spruce beetle activity on National Forest and private lands along the **Taku River** has subsided after four years of activity. There were only 90 acres of light activity recorded in 1998, compared to 4,545 acres in 1997, and 4,850 acres in 1996. This recent beetle activity followed a large windthrow event that occurred in the fall of 1990. New windthrow events have occurred since 1990, providing new brood trees, but only a fraction of the number of trees wind-thrown in 1990.

No new mortality in **Glacier Bay** National Park (M245B) was aerially detected in 1998. Only 900 acres were detected along the west side of the ridge between Gustavus and Excursion Inlet in 1997. The infestation, which has been ongoing for more than ten years, seems to have run its course. The historic outbreak in lower Glacier Bay has impacted more than 30,000 acres, resulting in mortality as high as 75%. Wood rotting fungi, such as *Fomitopsis pinicola*, have rapidly infested beetle-

killed trees, resulting in bole breakage and numerous forest canopy gaps. Primary as well as secondary plant succession follows in these gaps, among the many jackstrawed tree boles and tops. Observations to date on Lester Island indicate that alder, Sitka spruce, and hemlock regenerate in these disturbed/altered stands.

Spruce beetle activity in the **Stikine River delta** area has decreased to only 30 acres compared to 785 acres in 1997. These infested acres were on Dry Island and Rynda Island.

Scattered, small-scale spruce beetle activity occurred on Baranof Island, and the Yakutat Forelands (245A).

Engravers

Ips perturbatus Eichh.
I. concinnus Mann.

Engraver activity increased by 15% in 1998 over 1997 levels of 8,088 acres. During 1998 aerial surveys, 9,290 acres of engraver impact were observed. 44% of this activity, 4,050 acres, was located along the North Fork of the Kuskokwim River (M131C). Two other notable areas, both along the Tanana River, accounted for the majority of the balance of engraver activity in interior Alaska. They were: Big Delta to Harding Lake (131B) at 421 acres and from Clear to Fairbanks (131A) at 238 acres.

Ips beetle activity in interior Alaska is most often associated with disturbances such as riverbank erosion, top breakage, logging, or wind. Along many of the Interior rivers, riverbank erosion is the precipitating event for small-scale outbreaks and much of the endemic activity. Such has been the case for much of the activity in the upper Yukon River valley and its associated drainages for the past several years. During 1998 aerial surveys, all of the recent, small-scale outbreaks, such as those on the Christian and Sheenjek Rivers, have declined to endemic levels.

In **southeast Alaska** no *Ips* infested trees were recorded in 1998.

DEFOLIATORS

Fewer defoliator plots (35 plots) were visited than in previous years (52 plots) during the 1998 aerial survey in Southeast Alaska. An effort was made to distribute these plots evenly across the archipelago.

The objectives were to:
* Spend more time covering the landscape during the aerial survey,
* Allow more time to land and identify unknown mortality and defoliation, and
* Avoid visit sites that were hard to get to and had few western hemlocks.

Hemlock Sawfly and black-headed budworm larvae counts were generally low in 1998. The highest sawfly larvae counts were from the plots in Thorne Bay and Bay of Pillars. Larval counts are used as a predictive tool for outbreaks of defoliators. For example, if the larval sample is substantially greater in 1999, then an outbreak would be expected in 2000

Spruce Budworm

Choristoneura fumiferana (Clemens)
Choristoneura orae (Freeman)

Acres of defoliation attributed to the eastern spruce budworm rose in 1998 by 129%. All of the 87,800 acres of budworm defoliation observed occurred along the Yukon River from Ruby to Weir Island (131A). The majority of this defoliator outbreak is concentrated in only 35 river miles. Upriver, from Weir Island to Stevens Village, no budworm activity was noted. This year's activity is consistent with the general pattern of this outbreak. That is, a general, annual southwestward migration downriver along the Yukon. Assuming parasites, predators and adverse weather conditions (the natural control agents of budworm populations) are unable to keep this population in check, there is good reason to believe this pattern will continue, as there remain contiguous spruce stands for hundreds of miles downriver.

Western Black-headed Budworm

Acleris gloverana Walsingham

The black-headed budworm is native to the forests of coastal and southwestern Alaska. It occurs primarily in southeast Alaska and has been documented there since the early 1900's. Budworm populations in Alaska have been cyclic, arising quickly, impacting vast areas, and then subsiding within a few years.

In southeast Alaska, a peak year for budworm defoliation occurred in 1993, totaling 258,000 acres. The last budworm outbreak of this magnitude occurred from the late 1940's to mid-1950's. Cool wet weather in early summer months retard growth and development of the budworm and may have resulted in population declines. Black-headed budworm populations crashed in 1995 with only 1,200 acres in 1997. In 1998, no budworm defoliation was aerially detected.

Due to adverse flying conditions, we were unable to examine forest health conditions in Prince William Sound (M244A, M245A) in 1998. In 1996 and 1997, approximately 30,000 acres of defoliation were observed. However, reports from ground personnel indicate that the recent outbreak of the western black-headed budworm has substantially declined. This is most likely due to the cool, wet weather the Sound experienced this spring. Inclement weather is often a major limiting factor in budworm outbreaks. We expect to survey this area in 1999.

Spruce Needle Aphid

Elatobium abietinum Walker

Spruce needle aphids feed on older needles of Sitka spruce, often causing significant amounts of needle drop (defoliation). Defoliation by aphids causes reduced tree growth and predisposes the host to other mortality agents, such as the spruce beetle. Severe cases of defoliation alone may result in tree mortality. Spruce in urban settings and along marine shorelines are most seriously impacted. Spruce aphids feed primarily in the lower, innermost portions of tree crowns, but may impact entire crowns during outbreaks. Outbreaks in southeast Alaska are usually preceded by mild winters.

Following the mild winter of 1991-92, spruce needle aphid populations expanded rapidly in southeast Alaska, causing over 25,000 acres of Sitka spruce defoliation. Populations crashed in 1993 due to extended periods with sub-freezing temperatures during January and February. After a slight resurgence of activity in 1994, the 1995 population levels were low. In 1996 and 1997 the acres of trees affected were 600 and 440, respectively. An outbreak occurred in 1998 following another mild winter, with 46,300 acres of defoliation. Southeast Alaska accounted for 44,300 acres with 39,100 of those acres on national forest lands. Of the area defoliated on the Tongass National Forest, 79%, 9%, and 12% were on the in Chatham, Stikine, and Ketchikan areas respectively.

Although spruce needle aphid defoliation occurs primarily along shorelines, in 1998 it extended up the slope in many areas, especially along the outer coast. The affected acres were concentrated on southern and western aspects (see the figure below).

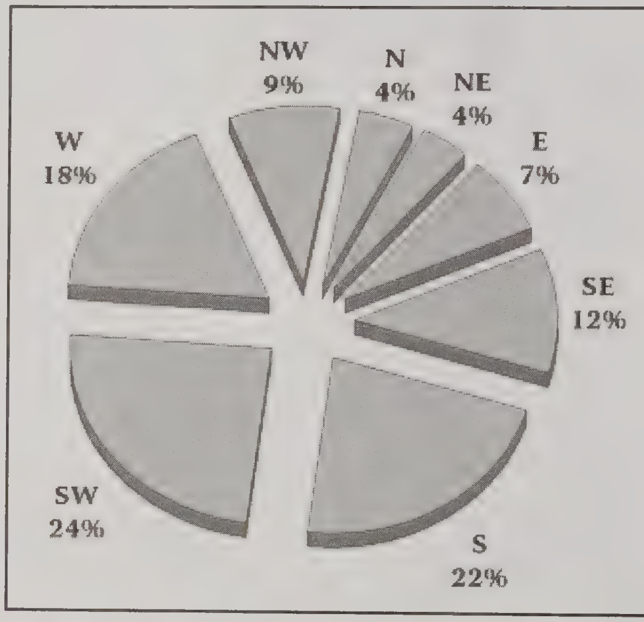
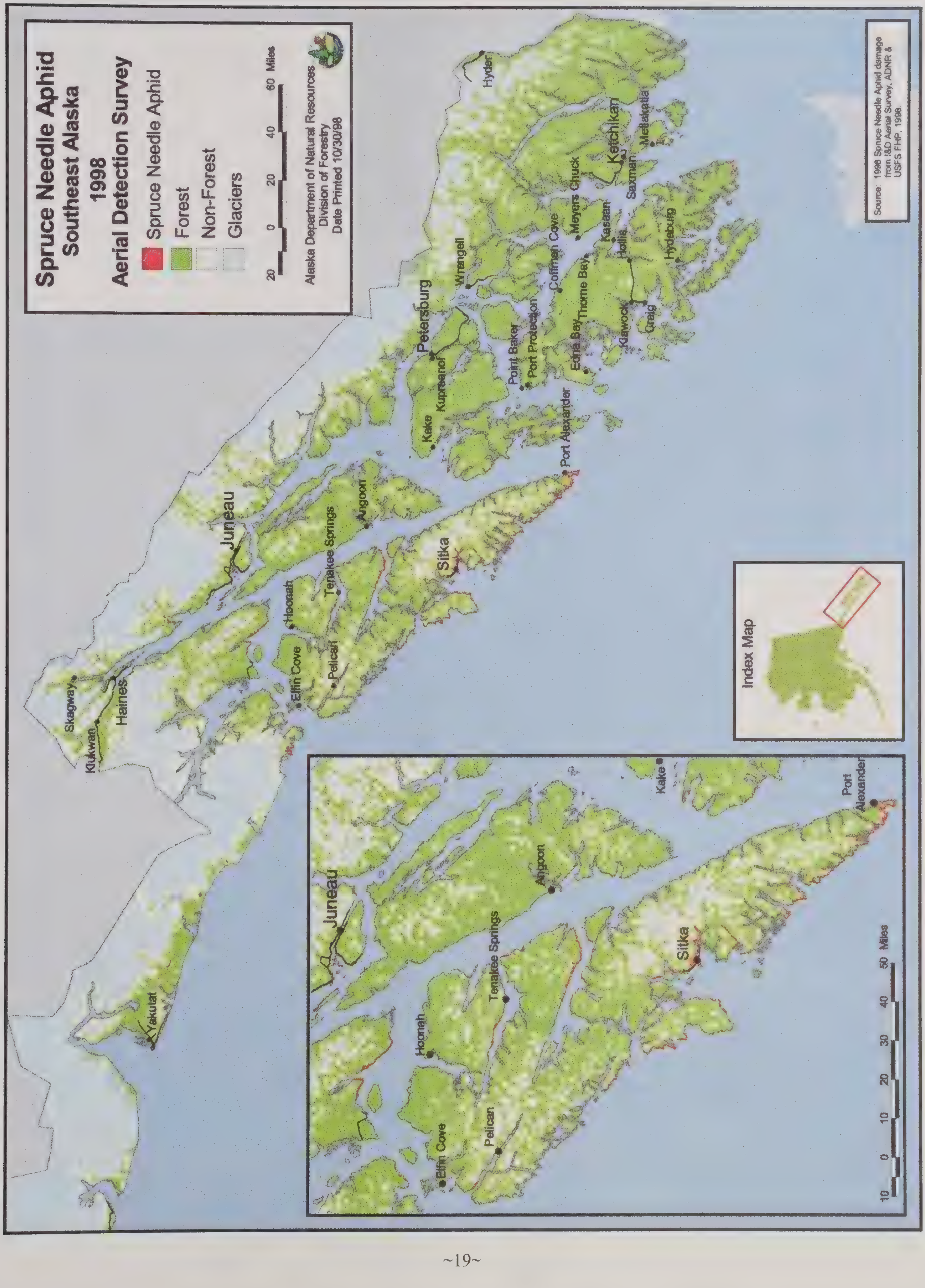


Figure 5. Percent of acres defoliated by spruce needle aphid in 1998 according to aspect.

Defoliation in the Chatham area totaled 30,700 acres. Affected areas include Baranof Island from Port Lucy on the southeast tip to half way up the west coast to Crawfish Inlet, and from Redoubt Lake to Nakwasina Sound. Defoliation occurred on most of the perimeter around Kruzof Island. Most of the defoliation on Chichagof Island, occurred on southwest aspects of Khaz Peninsula, Peril Strait, Tenakee Inlet, and Lisianske Inlet. On Admiralty Island, defoliation was localized between Whitewater Bay and Kootznahoo Inlet. Defoliation in the Juneau area was from Berners Bay to Bishop Point. Along the shores of Icy Strait most of the acreage was on southern aspects along the north side of the strait. Most of the outer mainland defoliation occurred between Icy Point and Cape Spencer. An outbreak occurred near Yakutat on the eastern edge of the Yakutat Forelands at Deception Hills, Italia Lake, and Situk Lake.



Spruce Needle Aphid
Southeast Alaska
1998
Aerial Detection Survey
Spruce Needle Aphid
Forest
Non-Forest
Glaciers
20 0 20 40 60 Miles
Alaska Department of Natural Resources
Division of Forestry
Date Printed 10/30/98
Source: 1998 Spruce Needle Aphid damage from I&D Aerial Survey, ADNR & USFS FHP, 1998
Index Map
Skagway
Klukwan
Haines
Yakutat
Juneau
Hoonah
Elfin Cove
Pelican
Tenakee Springs
Angoon
Sitka
Port Alexander
Kake
Kupreanof
Petersburg
Wrangell
Point Baker
Port Protection
Edna Bay
Coffman Cove
Thorne Bay
Meyers Chuck
Kasaan
Klawock
Craig
Hollis
Hydaburg
Saxman
Ketchikan
Metlakatla
Hyder
10 0 10 20 30 40 50 Miles

Defoliation in the Stikine area was scattered over 3600 acres. Larger areas of activity occurred on Kuiu Island from Saginaw Bay to the Bay of Pillars and on Wrangell Island along Zimovia Strait.

Defoliation in the Ketchikan area totaled 4800 acres affecting Prince of Wales Island mostly south of Soda Bay on the west side and south of Cholmondeley Sound on the east side. On Revillagigedo Island defoliation occurred from Mountain Point to Neets Bay. There were only small spots of activity on Dall, Suemez, San Fernando, Heceta, and Kupreanof Islands.

Hemlock Sawfly

Neodiprion tsugae Middleton

Hemlock sawflies, common defoliators of western hemlock, are found throughout southeast Alaska. Historically, sawfly outbreaks in southeast Alaska have been larger and of longer duration in areas south of Frederick Sound (M245B).

Unlike the larvae of the black-headed budworm, hemlock sawfly larvae feed in groups, primarily on older hemlock foliage. These two defoliators, feeding in combination, have the potential to completely defoliate western hemlock. Heavy defoliation of hemlock by sawflies is known to cause reduced radial growth and top-kill. Hemlock sawflies may ultimately influence both stand composition and structure in some areas. The sawflies themselves are a food source for numerous birds, other insects, and small mammals.

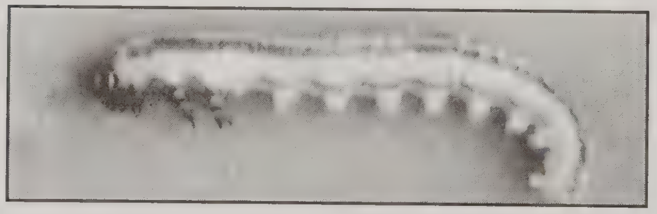


Figure 6. Hemlock sawfly larvae

In 1998, sawfly defoliation decreased 59% from 1997 levels. A total of 3920 acres were detected in 1998. Most of the recent defoliation was classified as medium in intensity. Most of the defoliation in 1998 (2,500 acres) occurred between Security Bay and Rowan bay on Kuiu Island, Stikine Area. A small amount of defoliation occurred in the Southeast end of Wrangell Island at Thom's Place and The Narrows. Only 400 acres of activity were recorded in the Ketchikan Area at Kendrick Bay (Prince of Wales Island), at American and North Bays (Dall Island), and at Eagle Bay (Bradfield Canal). Defoliation in the Chatham Area (950 acres) was on Admiralty Island at Chapin Bay and Thayer Lake.

Larch Sawfly

Pristiphora erichsonii (Hartig)

Total acres of land affected by larch sawfly in 1998 were 461,780 acres. This represents a 58% increase over reported levels in 1997 of 267,000 acres. This increase reflects not so much an increase of area affected, but a different way of accounting for the insect activity. Although larch stocking levels are low across much of its distribution, nearly all susceptible larch in a given stand are affected by the larch sawfly. Therefore, in 1998, the total area of land affected was considered to be the area impacted by the larch sawfly.

The area of most intense activity remains the vast area between McGrath and the Alaska Range (131B) where 426,240 acres of defoliation were observed. The defoliation noted in 1997 from Delta Junction to Tanana remained nearly the same for 1998. However, after six years of heavy defoliation, larch mortality is beginning to appear. The concern still exists that larch beetle may begin to build up in these heavily defoliated stands which could result in further mortality. Due to extremely high water levels in the rivers with the resultant large volume of debris in the water, it was deemed unsafe to attempt river landings to conduct ground checks.

Rusty Tussock Moth

Orygia antigua (L.)

In 1998, the Rusty Tussock Moth resumed endemic populations. No additional reports of defoliation were received. The Rusty Tussock Moth was found, in the Mat-Su Valley (213B) in 1997, defoliating spruce, hardwoods, and ground vegetation such as blueberry.

Birch Defoliation

Fenusa pusilla (Lepeletier)
Euceraphis betulae (Koch.)

For the second consecutive year, birch defoliation was very noticeable in the Anchorage Bowl and the

Mat-Su Valley (213B) in late July and early August. Since hardwoods have the ability to produce additional leaves each year, defoliation must occur for several consecutive years or be accompanied by consecutive years of drought to cause any lasting damage.

The birch leafminer was first reported in eastern United States in 1923. It came from Europe and has rapidly spread throughout the northern United States, Canada, and Alaska. The adult sawfly is black, about 3 mm long, and is similar in appearance to a common fly. Larvae overwinter in cocoons in the soil and adults appear in the spring when the first birch leaves are half grown. The female sawfly deposits her eggs singly on newly developing leaves. At times, almost every leaf is mined by the developing larvae, giving it a brown color. When mature, the larva cuts a hole through the leaf and drops it to the ground. There the larvae build a cell in which pupation takes place; 2-3 weeks are usually required for transformation into the adult stage. A re-flushing of leaves may occur, and a second generation of egg-laying sawflies may develop. Two to four generations of this insect can develop in northeastern US; the number of generations in Alaska is not known.

Large populations of birch aphid are responsible for honeydew, leaf-curling, and browning. Birch aphids are small and greenish-brown; they may be winged or wingless. Aphids usually over-winter as eggs, hatch in the spring as females which can reproduce without mating, and give birth to live young. Aphids are very responsive to changes in temperature. During warm dry summers, enormous aphid populations can appear in a relatively short time. Although this summer was not as warm and dry as last year, populations were still high enough to be readily noticeable. Even so, aphid damage to Alaska birch forests is negligible.

Large Aspen Tortrix

Choristoneura conflictana Wlkr.

Large aspen tortrix populations continue the up and down pattern exhibited for a number of years. In 1998, numbers were up again, to 22,730 acres. This represents a 337% increase over 1997 levels. Tortrix defoliation was noted in several areas throughout the interior. Harding Lake (131B) at 490 acres, Salcha River (131B) at 388 acres and Livengood (M139A) at 100 acres were the smaller areas observed. South of Fairbanks at Clear (131B), 1,189 acres were mapped. The area of most intense tortrix defoliation in the interior was in the vicinity of Northway. From Northway to Cathedral Rapids (M139C) along the Alcan Highway, 3,342 acres of defoliation were noted and south of Northway, along the Nabesna River (M139C), 1,790 acres were observed. The majority of the balance of tortrix defoliation was located on the Kenai Peninsula, from Kenai north to Point Possession (213B). There, 14,245 acres of defoliation was noted.

Gypsy Moth

Lymantria dispar (L.)

The european gypsy moth was accidentally introduced into the eastern U.S. in the late 1800's. Since then, the gypsy moth has been responsible for considerable damage to the hardwood forests of the east. The gypsy moth has been also introduced out west where millions of dollars have been spent on its eradication.

Since 1986, Forest Health Protection, in conjuction with Alaska Cooperative Extension and USDA APHIS, have placed gypsy moth pheromone monitoring traps throughout Alaska. To date, only two European gypsy moths have been trapped in Alaska. As far as we know, however, populations of the gypsy moth have not been established in Alaska. Due to the detection of the Asian gypsy moth (a more damaging race of the European gypsy moth) in the Pacific Northwest, more than 200 detection traps were placed throughout Alaska in 1998. No Asian or european gypsy moths were collected. If the Asian gypsy moth becomes established in the western U.S., including Alaska, the potential impacts to forest and riparian areas could be tremendous. The trapping program will be continued next year.

Cottonwood Leaf Beetle

Chrysomela spp.

Heavy cottonwood defoliation by the cottonwood leaf beetle was observed throughout the Anchorage Bowl (213B). FHP staff and Alaska Cooperative Extension personnel received numerous calls from concerned citizens regarding the defoliation and the larvae. The feeding larvae are black, segmented grubs which produce two rows of white dots along their back. Larvae skeletonize the leaves by feeding on the surface of the leaf, resulting in a scorched appearance. The adults beetles are black

Figure 7. 1998 Spruce needle aphid defoliation near Sitka, Alaska.

Figure 8. Larch sawfly defoliation.

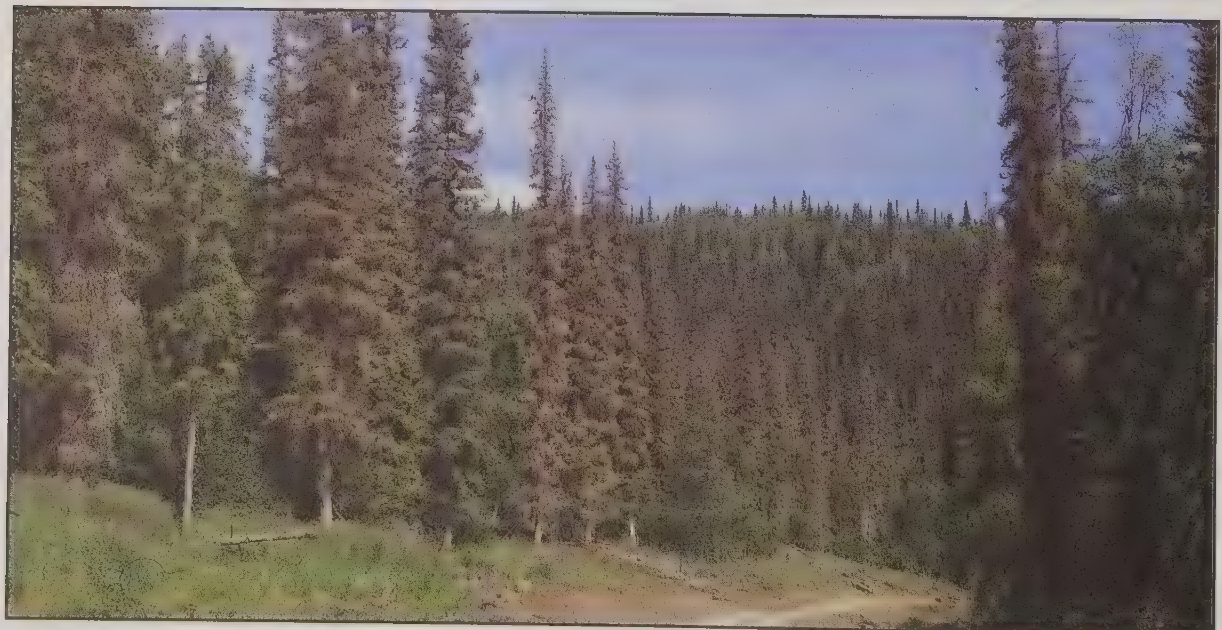


Figure 9. Spruce budworm defoliation.

with orange markings and are often mistaken for large ladybug beetles. Adults overwinter in leaf litter. Removal of leaf litter can help to reduce beetle numbers.

Alder Woolly Sawfly

Eriocampa ovata (L.)

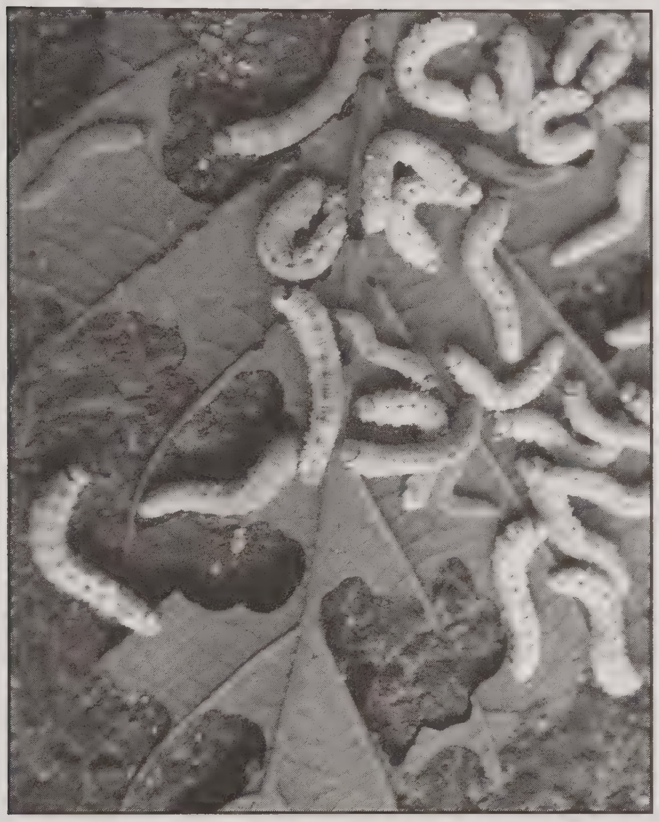


Figure 10. Alder woolly sawfly larvae.

Heavy to moderate defoliation of Sitka and thinleaf alder was observed for the second consecutive year in many parts of the Anchorage Bowl (213B). Heavy defoliation was also observed throughout southeast Alaska on red alder. This sawfly is a European species now established throughout the northern U.S., Canada, and Alaska. The larvae are covered with a distinctive shiny, woolly secretion. They skeletonize the lower leaves on young alders; the upper crown is usually not fed upon. Populations are expected to decline next year as a result of this summer's cool and wet conditions.

Willow Leaf Blotchminer

Micrurapteryx salicifolliela (Lepidoptera: Gracillaridae)

The outbreak of the willow leaf blotchminer, which peaked at 150,000 acres in 1991 then fell to endemic levels of only 3,502 acres in 1997, rose dramatically again in 1998. This year, observable populations rose 3,414% to 123,070 acres. As in the past, the majority of the blotchminer activity is located in the upper Yukon River Flats area (139A) and the rivers which drain into the Yukon throughout this region. All but approximately 10,000 acres of the total acreage are located within this area. The affected drainages are as follows: Porcupine River - 26,256 acres; Chandalar River - 17,326 acres; Christian River - 19,066 acres; Sheenjek River - 11,303 acres; Coleen River - 957 acres and the Black River - 8,240 acres. Within the Yukon Flats, from Fort Yukon to Stevens Village along the Yukon River, 16,307 acres of willow defoliation was observed and from Stevens Village to Tanana (M139A), 6,821 acres. In other parts of the interior, the Kantishna River (131A) had 3,581 acres, and the Minto Flats area (131A) accounted for 2,802 acres. The infestation of the blotchminer probably covers many more acres than actually observed. Oftentimes, the brown-appearing, defoliated willow stretches as far as one can see from the air; however, cost prohibits more thorough coverage. Some willow mortality has been observed and the concern remains that widespread mortality may have a detrimental effect on availability of willow sprouts, upon which moose depend heavily as a food source.

Spotted Tussock Moth

Lophocampa maculata (Harris)

Moderate defoliation of blueberry (*Vaccinium* sp.) and Sika alder (*Alnus sinuata*) has observed during the summer of 1997 and 1998 from Wrangell Island south to Ketchikan. The causal agent was determined to be the spotted tussock moth (*Lophocampa maculata* (Harris)). The name Spotted comes for the spotted fore wings of the adult (white spots on a buff background). The name Tussock refers to the long tufts of hair that extend beyond the body of the caterpillar. The mid-abdominal segments of the early instar caterpillars have red hairs among bright yellow hairs. The anterior and posterior have long wisps of white hairs with shorter yellow and black hairs. The mid-abdominal segments of the late instar has wisps of long white hairs among reddish-orange hairs; the anterior and posterior is predominantly black with long wisps of white hairs among short black hairs. They are commonly known elsewhere as woolly bears. The gray cocoon formed from the long body hairs and silk probably overwinter in the leaf litter layer. The adult probably emerges in spring. Different forms of this Lepidopteran live throughout western North America.

MISCELLANEOUS FOREST INSECTS

Hawkmoth

Hyles galii (Rottenburg)

Moderate to heavy defoliation of fireweed (*Epilobium* spp.) and other perennials by the larvae has been observed throughout Alaska. The larval body is black with a red head, horn, and eyespots (along body). Body also has rows of small yellow spots. The adult is a good flyer with pale band down the middle of the fore-wing and red in the hind-wing (Figure 11). The adults feed on flower nectar. Adults are seen from May to August. Larvae feed on fireweed until late fall then over-winter as a coccoon in the leaf litter. May people are frightened and delighted by the moth that appears to fly like a bird and not like a moth. This hawkmoth is known as the bedstraw hawkmoth because it feeds upon bedstraw (*Galium* spp.)and is found across North America from the east coast to Colorado and California, north to the Canada and Alaska.

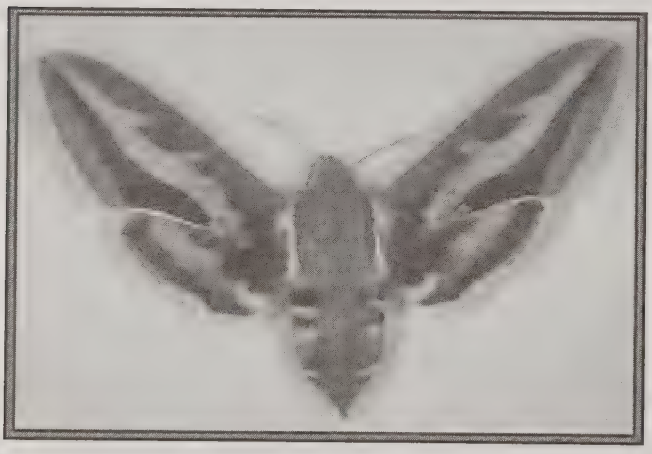


Figure 11. Sphinx moth or also commonly known as a hawkmoth. Photo by Paul Opler.

Sitka Spruce Weevil

Pissodes strobi Peck

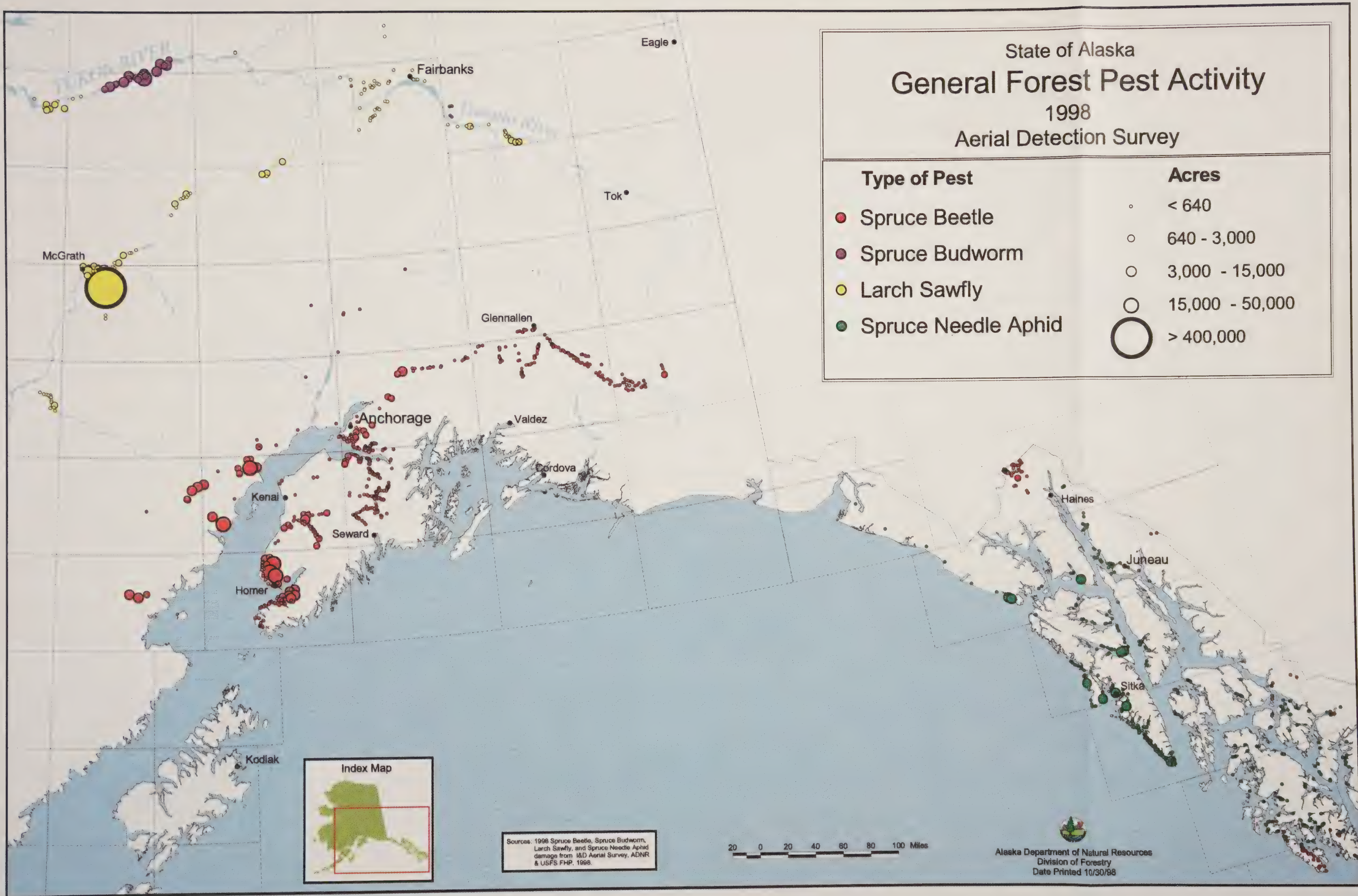
Adult Sitka spruce weevils were collected for the first time in the Anchorage Bowl in 1995 and again in 1996-97. The weevils were collected from infested nursery stock (blue spruce) brought into the state from the Pacific Northwest. Developing larvae, pupae, and callow adults were encountered last summer in out-plantings of spruce in west Anchorage; an indication that the spruce weevil may have adequate developmental conditions to become established in south-central Alaska. A ground check undertaken this summer in the west Anchorage area found no new Sitka spruce weevil activity on new out-plantings. All of the infested shoots seen in this area last summer had been clipped and disposed of. We will continue to monitor the potential establishment of this serious pest of ornamental and native spruce.

Spruce Needleminer

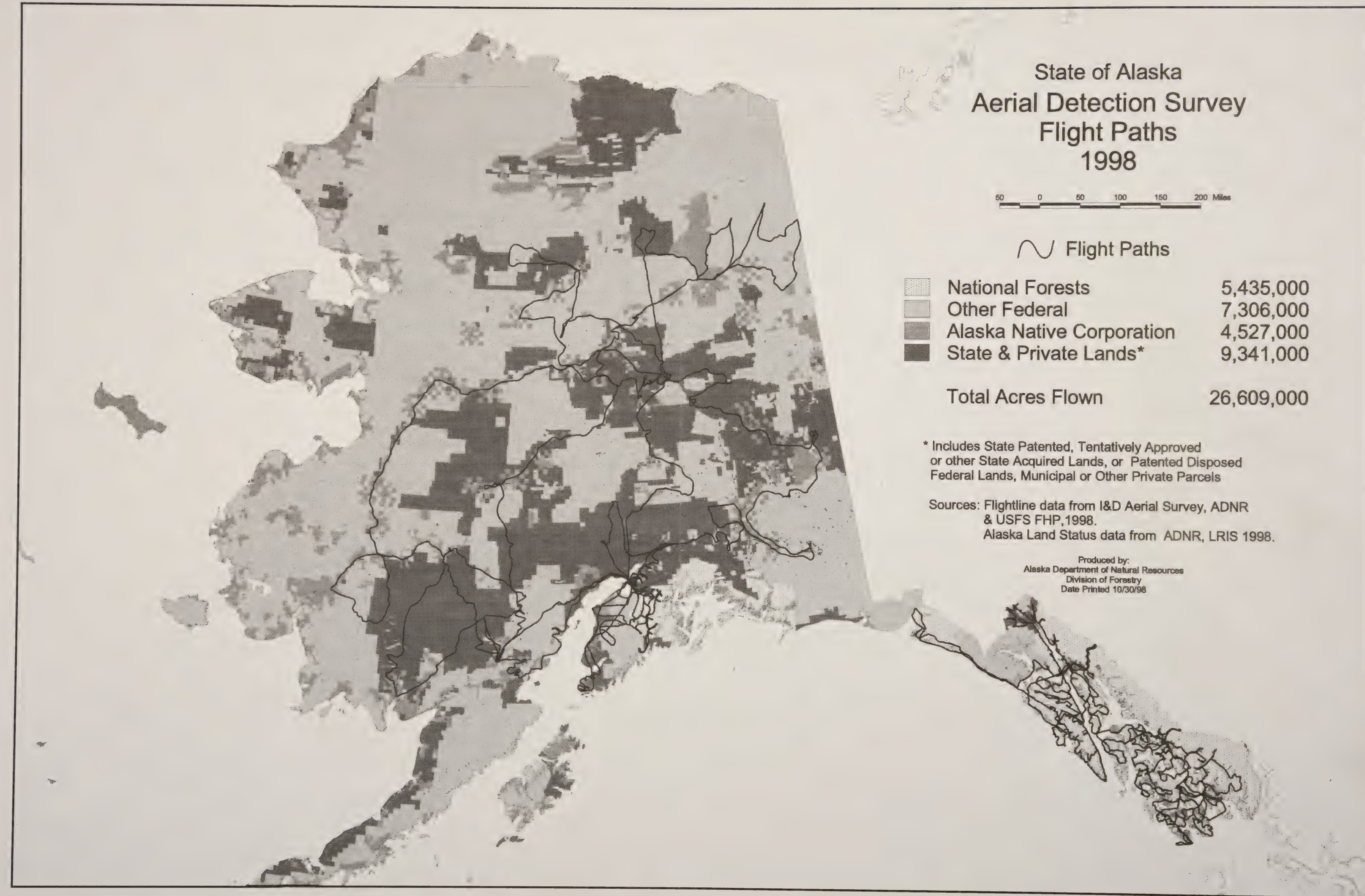
Endothenia albolineana (Kearfott)

The Anchorage IPM Technicians (Alaska Cooperative Extension) first noticed in 1997 spruce needleminers in Anchorage on imported nursery stock. In 1998, large numbers of needleminers were noticed outside of greenhouse settings and in several areas throughout Anchorage on ornamental outplantings. This is the first time this insect has been reported in south-central Alaska. This needleminer is widely distributed in the spruce growing regions of the United States and Canada. It is primarily a problem for Christmas tree growers and arborists.

The needleminer produces one generation per year with larvae overwintering in hollowed-out needles. Larval feeding resumes the following spring. When the interior of a needle has been consumed, the larva often cuts it off; the needle remains attached to the other dead needles by silk threads.



State of Alaska
General Forest Pest Activity
1998
Aerial Detection Survey
Type of Pest
Spruce Beetle
Spruce Budworm
Larch Sawfly
Spruce Needle Aphid
Acres
< 640
640 - 3,000
3,000 - 15,000
15,000 - 50,000
> 400,000
Eagle
Fairbanks
Tok
McGrath
Glennallen
Anchorage
Valdez
Cordova
Kenai
Seward
Homer
Kodiak
Haines
Juneau
Sitka
Index Map
Sources: 1998 Spruce Beetle, Spruce Budworm, Larch Sawfly, and Spruce Needle Aphid damage from I&D Aerial Survey, ADNR & USFS FHP, 1998.
20 0 20 40 60 80 100 Miles
Alaska Department of Natural Resources
Division of Forestry
Date Printed 10/30/98


State of Alaska
Aerial Detection Survey
Flight Paths
1998
50 0 50 100 150 200 Miles
Flight Paths
National Forests 5,435,000
Other Federal 7,306,000
Alaska Native Corporation 4,527,000
State & Private Lands* 9,341,000
Total Acres Flown 26,609,000
* Includes State Patented, Tentatively Approved or other State Acquired Lands, or Patented Disposed Federal Lands, Municipal or Other Private Parcels
Sources: Flightline data from I&D Aerial Survey, ADNR & USFS FHP,1998.
Alaska Land Status data from ADNR, LRIS 1998.
Produced by:
Alaska Department of Natural Resources
Division of Forestry
Date Printed 10/30/98

STATUS OF DISEASES

ECOLOGICAL ROLES OF FOREST DISEASES

The economic impacts of forest diseases in Alaska have been recognized for some time. In southeast Alaska, heart rot fungi cause substantial cull, nearly 1/3 of the gross volume, in old-growth spruce-hemlock forests. Also the high level of cull in white spruce and paper birch forests in the south-central and interior regions are considered severe limitations on the availability and cost of harvesting timber. Traditionally, management goals included eliminating or reducing disease to minimal levels. This perspective, however, ignores the functional ecological roles of disease in Alaska's forest ecosystems.

We are learning that diseases are key ecological factors in Alaskan ecosystems, enhancing diversity, providing wildlife habitat, and altering forest structure, composition, and succession. As agents of disturbance in the western hemlock/Sitka spruce forests of southeast, diseases are apparently responsible for the "breaking up" of even-aged stands as they are in transition (i.e., 150 to 200 years old) to old-growth phase. Then, they appear to be the among the primary factors that maintain stability in the old-growth phase through small-scale (canopy-gap) level disturbance. Although less is known about the ecological role of diseases in south-central and interior forests, diseases appear to be important factors in the transition of even-aged hardwood forests to mixed conifer/hardwood forests. Also, diseases, particularly root diseases, alter successional patterns at all development stages in white spruce forests.

To reduce disease to minimal levels in all instances is to diminish the various desirable forest structural characteristics and ecosystems functions that they influence. Disease control may lead to simplified, homogeneous conditions that are not desirable for many resources. In some cases, uniform forests lacking endemic disease may be more susceptible to epidemics of other organisms. On the other hand, overly abundant levels of some diseases negatively affect nearly all resources. For example, hemlock dwarf mistletoe can build to excessive levels in stands lacking external disturbance. As a result canopy collapse can occur through a process of retarded height growth of all overstory trees. Thermal cover and vertical structure are altered so that even resources such as habitat for most wildlife are reduced.

Two of the principal types of disease that alter forest structure in Alaska, heart rot and dwarf mistletoe, can apparently be managed to predictable, desirable levels. If reducing disease to minimal levels is a management objective, then both heartrot and mistletoe can be largely eliminated for many decades or centuries by clearcut harvesting and even-aged management. Managers need to consider that these organisms can take a long time to recolonize clearcut sites, especially hemlock dwarf mistletoe. If structural and biological diversity are included as objectives for management, then desirable levels of disease can be attained through different strategies of selective harvesting. Most heart rot in coastal stands is associated with natural bole scars and top breakage. Levels of heart rot can be manipulated by controlling the incidence of bole wounding and top breakage during stand entries for timber removal. Levels of dwarf mistletoe can be manipulated through the distribution, size, and infection levels of residual trees that remain after alternative harvests. Our ongoing research indicates that the incidence and effects of these diseases will vary through time in a predictable manner by whatever silvicultural scheme is used. One of our objectives in ecosystem management is to develop the tools for managing moderate disease levels that will conserve essential ecosystem processes, enhance many resource values, but also maintain productivity of the timber resource.

Figure 12. Bole breakage caused by the heart rot fungus Ganoderma applanatum

Table 3. Suspected effects of common diseases on major ecological characteristics and processes in Alaskan forests. Effects by each disease of disorder are qualified as: - = negligible or minor effect, + = some effect, ++ = dominant effect.

ECOLOGICAL FUNCTION ALTERED

DISEASE	STRUCTURE	COMPOSITION	WILDLIFE SUCCESSION	HABITAT
STEM DISEASES				
Dwarf mistletoe	++	+	+	++
Hemlock cankers	-	+	=	+
Hardwood cankers	+	+	+	-
Spruce broom rust	+	=	=	++
Hemlock bole fluting	-	-	-	–
Western gall rust	-	-	-	-
HEART ROTS				
(Many species)	++	+	++	++
ROOT DISEASES				
(several species)	+	++	++	+
FOLIAR DISEASES				
Spruce needle rust	-	-	-	-
Spruce needle blights	-	-	-	-
Hemlock needle rust	-	-	-	-
Cedar foliar diseases	-	-	-	-
Hardwood leaf diseases	-	-	-	-
SHOOT DISEASES				
Sirococcus shoot blight	-	-	-	-
Shoot blight of yellow-cedar	-	+	-	-
DECLINES				
Yellow-cedar decline	++	++	++	+
ANIMAL DAMAGE				
Porcupines	+	-	-	+
Brown Bears	+	-	-	+
Moose	+	+	-	+

Figure 13. Yellow-cedar decline in southeast Alaska.

Figure 14. Stem decay of paper birch caused by the cinder conk, Inonotus obliquus

Figure 15. Dark fungal staining of yellow-cedar heartwood.

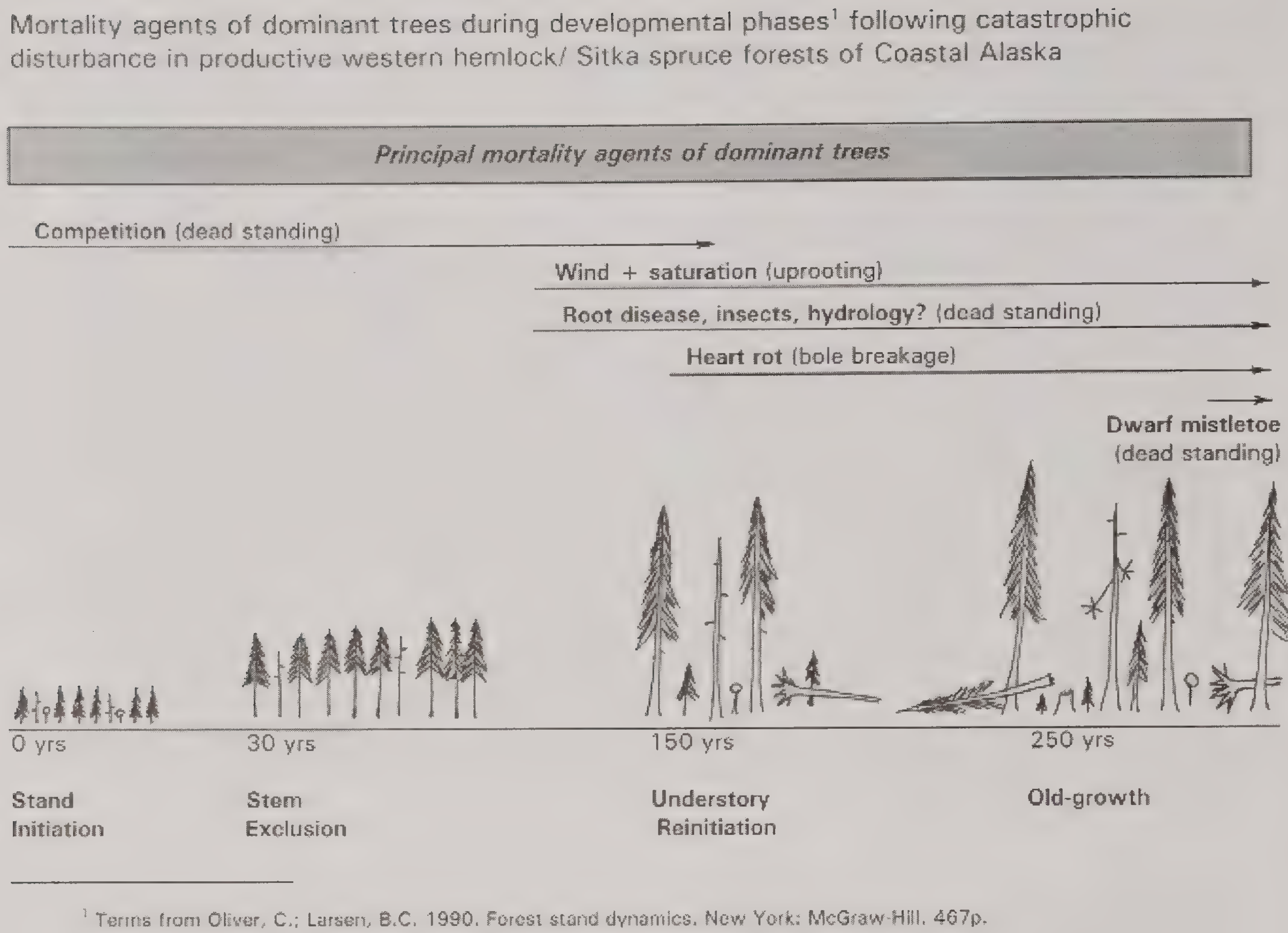


Figure 16. Role of diseases in forests development following disturbances in coastal Alaska.

Diseases perform a vital role in the developmental stages following catastrophic disturbance. (e.g., large-scale windthrow, clearcut harvest) in the forests of coastal Alaska. Terms of stand development stages are from Oliver, C. and Larsen, B.C., 1990, Forest Stand Dynamics, McGraw-Hill, New York, 467p. Note the lack of major influence of disease in early successional stages where most mortality is through competition. Numerous diseases are present (e.g., foliar and shoot diseases) at these early successional stages, but none has a predominant effect on forest development. By contrast, diseases appear to be major mortality factors (i.e., disturbance agents) in the understory reinitiation stage. This stage can be interpreted as the transition from even-aged stands breaking up to enter the old-growth stage. Disease appears to be responsible for initiating this change by killing dominant and codominant trees. Heart rot fungi appear to play a critical role in the maintenance of old-growth by inducing bole breakage which is one of the most common forms of canopy gap level disturbance in old coastal forests. It is conceivable that hemlock dwarf mistletoe intensifies as a stand persists in the old-growth condition for many centuries, reaching such high disease levels that vertical structure and productivity are eroded through time. Thus, the old-growth stage in coastal Alaska may be either sustained by disease in a sort of dynamic equilibrium through the canopy gap process or it may be continually altered until the next catastrophic disturbance. Research is currently evaluating the above proposed scenario.

STEM DISEASES

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendhal) G.N. Jones

Hemlock dwarf mistletoe is an important disease of western hemlock in unmanaged, old-growth stands throughout southeast Alaska as far north as Haines. Although the range of western hemlock extends to the northwest along the Gulf of Alaska, dwarf mistletoe is absent from Cross Sound to Prince William Sound (M244A, 245A, and M245A)*. The incidence of dwarf mistletoe varies in old-growth hemlock stands in southeast Alaska from stands in which every mature western hemlock tree is severely infected to other stands in which the parasite is absent. The dominant small-scale (canopy gap) disturbance pattern in the old forests of coastal Alaska favors the short-range dispersal mechanism of hemlock dwarf mistletoe and may explain the common occurrence of the disease here. Infection of Sitka spruce is uncommon and infection of mountain hemlock is rare. The disease is uncommon on any host above elevations of approximately 1,000 feet. Heavily infected western hemlock trees have branch proliferations (witches' brooms), bole deformities, reduced height and radial growth, less desirable wood characteristics, greater likelihood of heart rot, top-kill, and severely infected trees may die. This year, we found the aggressive heart rot fungus *Phellinus hartigii* associated with large mistletoe brooms on western hemlock.

These symptoms are all potential problems in stands managed for wood production. Growth loss in heavily infested stands can reach 40% or more. On the other hand, witches' brooms, wood decay associated with bole infections, and scattered tree mortality can result in greater diversity of forest structure and increased animal habitat. Witches' brooms may provide hiding or nesting habitats for birds or small mammals, although this topic has not been adequately researched in Alaska. The inner bark of swellings and the seeds and shoots of the parasitic plants are nutritious and often consumed by small mammals (e.g., most likely flying squirrels). However, heavily infected hemlock stands can begin to decline and collapse to the extent that vertical structural diversity and animal habitat are diminished. Stand composition is altered when mixed-species stands are heavily infected; growth of resistant species such as Sitka spruce and cedar is enhanced.

Figure 17. Hemlock dwarf mistletoe brooms in a dead western hemlock.

Spread of the parasite into young-growth stands that regenerate following "clear cutting" is typically by: 1) infected non-merchantable hemlock trees (residuals) which are sometimes left standing in cut-over areas, 2) infected old-growth hemlocks on the perimeter of cut-over areas, and 3) infected advanced reproduction. Residual trees may play the most important role in the initial spread and long-term mistletoe development in young stands. Managers using alternative harvest techniques (e.g., large residuals left standing in clearcuts, small harvest units, or partial harvests) should recognize the potential reduction in timber volume and value from hemlock dwarf mistletoe under some of these silvicultural scenarios. But substantial reductions to timber are only associated with very high disease levels. High levels of hemlock dwarf mistletoe will only result if numerous, large,

* The number following place names refer to ecosystem section designations. Refer to page 6 and Appendix D.

intensely-infected hemlocks are well-distributed after harvest. Mistletoe management appears to be a good tool in balancing several resource objectives. Selective harvesting techniques will be the silvicultural method for maintaining desirable levels of this disease if management intends to emphasize structural and biological diversity along with timber production.

Hemlock Canker

Xenomeris abietis Barr. and other fungi

Hemlock canker, which occurred at outbreak levels in southeast Alaska during the early 1990's, was conspicuous again in late 1998. In past outbreaks, it has been common along unpaved roads on Prince of Wales Island, Kuiu Island (Rowan Bay road system), Chichagof Island (Corner Bay road system) and near Carroll Inlet on Revillagigedo Island (M245B). It was also observed in several roadless areas. This year, it was reported to be common on the Rowan Bay road system of Kuiu Island.

The causal agent has not been conclusively determined. Road dust and a fungus appear to be responsible for outbreaks of this disease. Ecologically, stand composition and structure are the primary effects of hemlock canker. Tree species, other than western and mountain hemlock, are resistant and benefit from reduced competition. Wildlife habitat, particularly for deer, may be enhanced where the disease kills understory hemlock; which tends to out-compete the more desirable browse vegetation.

Spruce Broom Rust

Chrysomyxa arctostaphyli Diet.

Broom rust is common on spruce throughout interior and south-central Alaska but is found in only several local areas of southeast Alaska (e.g., Halleck Harbor area of Kuiu Island and Glacier Bay (M245B)). The disease is abundant only where spruce grow near the alternate host, bearberry or kinnikinnick (*Arctostaphylus uva-ursi*) in Alaska. The fungus cannot complete its life cycle unless both host types (spruce and bearberry) are present.

Infections by the rust fungus result in dense clusters of branches or witches' brooms on white, Lutz, Sitka, and black spruce. The actual infection process may be favored during specific years, but the incidence of the perennial brooms changes little from year to year.

The disease may cause slowed growth of spruce, although this has not been determined by research. Witches' brooms may serve as entrance courts for heart rot fungi, including *Phellinus pini*.

Ecologically, the dense brooms provide important nesting and hiding habitat for birds and small mammals. In interior Alaska, research on northern flying squirrels suggests that brooms in white spruce are an important habitat feature for communal hibernation and survival in the coldest periods of winter.

Western Gall Rust

Peridermium harknessii J.P. Moore

Infection by the gall rust fungus *P. harknessii* causes spherical galls on branches and main boles of shore pine. The disease was extremely common throughout the distribution of pine in Alaska in 1998 (M244B & C, M245B). Infected pine tissues are swollen but not always killed by the rust fungus. Another fungus, *Nectria macrospora*, colonized and killed many of the pine branches with *P. harknessii* galls this year. The combination of the rust fungus and *N. macrospora* frequently caused top-kill. The disease, although abundant, does not appear to have a major ecological effect in Alaskan forests.

HEART ROTS OF CONIFERS

Heart rot decay causes enormous loss of wood volume in Alaskan forests. Approximately 1/3 of the old-growth timber volume in southeast Alaska is defective largely due to heart rot fungi. These extraordinary effects occur where long-lived tree species predominate in such as old-growth forests in southeast Alaska. The great longevity of individual trees allows ample time for the slow-growing decay fungi to cause significant amounts of decay. Wood decay fungi play an important role in the structure and function of coastal old-growth forests where fire and other forms of catastrophic disturbance are uncommon. By predisposing large old trees to bole breakage, these fungi serve as important disturbance factors that cause small-

scale canopy gaps. All major tree species in southeast Alaska have been found killed in this manner.

In south-central and interior Alaska, heart rot fungi cause considerable volume loss in white spruce forests. Wood recovery studies in mature (120-200 year old) spruce where bark beetles have killed large proportions of stands on the Kenai Peninsula indicate that volume losses caused by heart rot fungi exceeded defect from sap rot fungi. We have a limited understanding, however, of the role of heart rot fungi in forest development. In the boreal forests, large-scale disturbance agents, including wildfire, insect outbreaks (e.g., spruce beetle), and flooding, are key factors influencing forest structure and composition. The importance of small-scale disturbances caused by decay fungi is unknown but currently under study.

Figure 18. Fomitopsis pinicola conk, a common spruce and hemlock heart rot agent.

Heart rot fungi enhance wildlife habitat — indirectly by increasing forest diversity through gap formation and more directly by creating hollows in live trees or logs for species such as bears and cavity nesting birds. Wood decay in both live and dead trees are centers of biological activity, especially for small organisms. Wood decay is the initial step in nutrient cycling of wood substrates, has associated bacteria that contribute nitrogen fixation, and contributes large masses of stable structures (e.g., partially modified lignin) to soils.

The importance of decay fungi in managed young-growth conifer stands is uncertain. Wounds on live trees caused by logging activities allow for the potential of decay fungi to cause appreciable losses. Heart rot in managed stands can be manipulated to desirable levels by varying levels of bole wounding and top breakage during stand entries. In some instances, bole breakage is sought to occur in a specific direction (e.g., across streams for coarse woody debris input). Artificially wounding trees on the side of the bole that faces the stream can increase the likelihood of the eventual tree fall in that direction. In southeast Alaska, a study has been concluded that investigated how frequently fungi enter wounds of different sizes and the rate of subsequent decay in these wounded trees. Generally, larger, deeper wounds and larger diameter breaks in tops result in a faster rate of decay. Results indicate that heart rot development is much slower in southeast Alaska than areas studied in the Pacific Northwest.

In southeast Alaska, the following fungi are the most important causes of wood decay in live trees:

Western hemlock

Fomitopsis pinicola
Laetiporus sulphureus
Phaeolus schweinitzii
Phellinus hartigii
Phellinus pini
Armillaria sp.

Sitka spruce

Fomitopsis pinicola
Phellinus pini
Phaeolus schweinitzii
Laetiporus sulphureus
Armillaria sp.

Western redcedar

Ceriporiopsis revulosa
Phellinus weirii

In south-central and interior Alaska, the following fungi are the most important causes of wood decay in live trees:

White and Lutz spruce

Fomitopsis pinicola
Phellinus pini
Coniophora sp.
Phaeolus schweinitzii
Laetiporus sulphureus
Pholiota sp.
Armillaria sp.

Mountain hemlock

Phellinus pini
Echinodontium tinctorium

Wood decay fungi decompose branches, roots, and boles of dead trees; therefore, they play an essential role in recycling wood in forests. However, sap rot decay also routinely and quickly develops in spruce trees attacked by spruce beetles, particularly trees with sloughing bark and wood checks. Large amounts of potentially recoverable timber volume are lost annually due to sap rot fungi on the Kenai Peninsula, where salvage logging has not kept pace with tree mortality from the continuing spruce beetle epidemic. Significant volume loss from sap rot fungi typically occurs several years after tree death. The most common sap rot fungus associated with spruce beetle-caused mortality is *Fomitopsis pinicola*, the red belt fungus.

STEM DECAY OF HARDWOODS

Stem decay is the most important cause of volume loss in Alaskan hardwood species. In south-central and interior Alaska, incidence of stem decay fungi is generally high by the time a hardwood stand has reached maturity. These fungi will limit harvest rotation age of forests that are managed for wood production purposes. Studies are currently underway in paper birch forests to identify the most important stem decay fungi and assess rates of decay as related to stand age and site conditions.

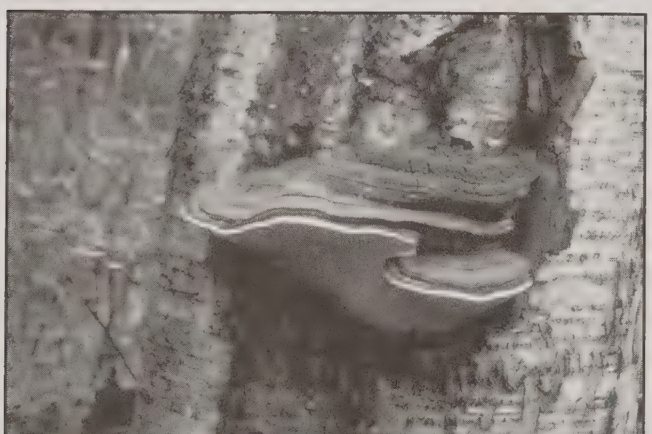


Figure 19. <u>Ganoderma applanatum</u> conk on paper birch.

Ecologically, stem decay fungi alter stand structure and composition and appear to be important factors in the transition of even-aged hardwood forests to mixed spruce-hardwood forests. Bole breakage of hardwoods creates small openings in the previously closed canopy, allowing spruce that were slowly growing in the understory to achieve dominance on a site. Habitat for birds and mammals is enhanced directly by the creation of cavities in live trees. Several mammals, including the northern flying squirrel, are known to utilize tree cavities year-round for nest and cache sites.

In south-central and interior Alaska, the following fungi are the primary stem decay causing organisms in live trees:

<u>Paper birch</u>
Phellinus igniarius
Pholiota sp.
Inonotus obliquus
Armillaria sp.

<u>Trembling aspen</u>
Phellinus tremulae
Pholiota sp.
Armillaria sp.

A number of fungi cause stem decay in balsam poplar, black cottonwood, and other hardwood species in Alaska.

SHOOT DISEASES

Sirococcus Shoot Blight

Sirococcus strobilinus Pruess.

Young-growth western hemlock shoots were killed in moderate levels by the blight fungus *S. strobilinus* in southeast Alaska during 1998. Sitka spruce and mountain hemlock were attacked but less frequently and less severely. Thinning may be of some assistance in reducing damage by the fungus as thinned stands have fewer infections than unthinned stands.

This disease is typically of minimal ecological consequence because infected trees are not often killed and young hemlock stands are so densely stocked. Species composition may be altered to some degree where trees other than western hemlock may be favored by the disease.

Shoot Blight Of Yellow-cedar

Apostrasseria sp.

Yellow-cedar regeneration suffered infection and shoot blight by the fungus *Apostrasseria* sp. in

southeast Alaska in 1998 as it does every year. The disease, however, does not affect mature cedar trees. Attack by the fungus causes terminal and lateral shoots to be killed back 10 to 20 cm on seedlings and saplings during winter or early spring. Entire seedlings up to 0.5m tall are sometimes killed. The newly discovered fungus that causes the disease, *Apostrasseria* sp., is closely related to other fungi that cause disease on plants under snow. The fungus *Herpotrichia juniperi* is often found as a secondary invader on seedlings after they die.

This shoot blight disease probably has more ecological impact than similar diseases on other host species because the natural regeneration of yellow-cedar is limited in many areas. By killing the leaders of yellow-cedar seedlings and diminishing their ability to compete with other vegetation, the pathogen reduces the regeneration success of yellow-cedar and thereby alters species composition.

Canker Fungi

Cryptosphaeria populina (Pers.) Sacc.
Cenangium singulare (Rehm.) D. & Cash
Ceratocystis fimbriata Ell. & Halst.
Cytospora chrysosperma Pers. ex Fr.
Nectria galligena

These fungi primarily cause trunk deforming cankers and wood decay of many hardwood species, particularly trembling aspen, in south-central and interior Alaska. Although most are considered weak parasites, *C. singulare* can girdle and kill a tree within six years. All the canker-causing fungi were at endemic levels in 1998.

Ecologically, canker fungi alter stand structure and composition through trunk deformity and bole breakage. Succession is altered as conifer trees will benefit from reduced competition.

FOLIAR DISEASES

Spruce Needle Blights

Lirula macrospora (Hartig) Darker
Lophodermium picea (Fuckel) Höhn.
Rhizosphaera pini (Corda) Maubl.

The fungus *Lirula macrospora* is the most important needle pathogen of spruce. In 1998 it occurred at moderate to low levels in most areas within the range of Sitka and white spruce. Throughout southeast Alaska, the disease was most common on young Sitka spruce and the lower crowns of larger trees. *Lophodermium picea* was present at low infection levels in 1998. This disease is more typical of larger, older trees of all spruce species in Alaska. *Rhizosphaera pini* continued at endemic levels after causing damage several years ago in coastal Alaska although it was associated with branch mortality at one site at Echo Cove near Juneau (M245B). Damage closely resembles that caused by spruce needle aphid, which was at epidemic levels this year, and microscopic observation of the tiny fruiting bodies on infected needles is necessary for proper identification.

The primary impact of these needle diseases is generally one of appearance. They can cause severe discoloration or thinning of crowns but typically have only negligible ecological consequence. However, repeated heavy infections may slow the growth of spruce and benefit neighboring trees, thereby altering species composition to some degree.

Spruce Needle Rust

Chrysomyxa ledicola Lagerh.
Chrysomyxa weirii Jacks.

Spruce needle rust, caused by *C. ledicola*, occurred at moderate levels across the state this year. Scattered small outbreaks occurred in white spruce across interior Alaska in 1998.

The spores that infect spruce needles are produced on the alternate host, Labrador-tea *(Ledum* spp.*)*, a plant that is common in boggy areas; thus the disease on spruce is most pronounced in these boggy (muskeg) areas. Although the disease can give spruce trees the appearance of being nearly dead, trees rarely die of this disease even in years of intense infection.

On Sitka spruce, the primary ecological consequence of the disease may be to reduce tree vigor of a species already poorly adapted to boggy sites. Repeated infection of spruce may alter forest composition by favoring other tree species.

The foliar rust fungus *C. weirii* was found sporulating on one-year-old Sitka spruce needles in several areas of southeast Alaska but it has never been

detected at threatening levels. Unlike most other rust fungi, no alternate host is necessary to complete its life cycle. Little ecological or economic impact results from this disease.

Hemlock Needle Rust

Pucciniastrum vaccinii (Rab.) Joerst.

Hemlock needle rust was found at endemic levels in 1998 after a high incidence two years ago. In 1996, the disease was most damaging near Yakutat (245A) where it caused defoliation of western hemlock, especially on trees growing adjacent to harvested sites. Elsewhere, infected needles were found, but hemlock trees were not heavily defoliated. The alternate hosts for the rust fungus include several blueberry species (*Vaccinium*). Infection levels usually return to endemic levels in a year or so and the disease is not expected to influence major ecological change.

Willow Rust

Melampsora epitea Thuem. complex

Willow rust, caused by several races of *Melampsora epitea*, occurred at moderate to high levels across the state in 1998. The primary outbreak was in the upper Yukon River Flats (139A), coinciding with the large outbreak of the willow leaf blotchminer across the same area. The rust fungus caused a yellow leaf spot or blight on most willow leaves per sprout.

Unlike many rust fungi, no alternative host is needed to complete its lifecycle. The rust fungus likely overwinters on willow buds, thus may occur at high levels again next year. Repeated rust infection of leaves may reduce host vigor.

Foliage Diseases Of Cedars

Gymnosporangium nootkatense Arth.
***Didymascella thujina* (Durand) Maire**

Two fungi that infect the foliage of cedar, *G. nootkatense* on yellow-cedar and *D. thujina* on western redcedar, occurred at endemic levels this year. *D. thujina* was the more damaging of the two and was common wherever its host was found. Neither fungus resulted in severe defoliation nor death of cedar trees. Neither disease has major ecological effects.

ROOT DISEASES

Several root diseases cause substantial volume loss and mortality of conifers and hardwoods in Alaskan forests. Infected trees are highly prone to uprooting, bole breakage, and outright mortality due to the extensive decay of root systems and the lower bole of trees. In stands managed for timber production, root rot fungi are considered long-term site problems because they remain alive in the roots of infected stumps for decades after harvest operations. Root disease pathogens affect groups of trees in progressively expanding disease centers. Typically, disease centers contain dead trees that have died within the last several years and living but infected trees in various stages of decline. Within centers, resistant tree species, including all hardwoods, are favored.

In south-central and interior Alaska, root disease exerts a major influence in early successional stages through mortality of spruce seedlings and saplings. After harvesting operations, root rot fungi remain on the site, harbored in infected spruce stumps. Spruce seedlings growing within close proximity of infected stumps have a high probability of becoming infected through root contacts. Root diseases appear to have an important role in late successional stages by slowly killing dominant or co-dominant trees and causing substantial decay of the butt log. In southeast Alaska, root disease impacts may be most apparent in the later successional stages (See Figure 16).

Ecologically, root diseases are considered natural, perhaps essential, parts of the forest altering stand structure, composition, and increasing plant community diversity. Resistant tree species, including all hardwood trees, benefit from reduced competition within infection centers. Wildlife habitat is enhanced by small-scale mortality centers, increased volume of large woody downed material, and increased hardwood browse vegetation.

The laminated root disease caused by a form of the fungus *Phellinus weirii*, so important in some western forests of British Columbia, Washington, and Oregon, is not present in Alaska. A non-root disease form of the fungus is present in southeast Alaska, where it causes a white rot in western redcedar, contributing to the very high defect of this tree.

Tomentosus Root Disease

Inonotus tomentosus (Fr.) Teng.

I. tomentosus causes root and butt-rot of white, Lutz, and Sitka spruce. The fungus can also attack lodgepole pine and black spruce. The disease is widespread in south-central and interior Alaska, but has not been found in southeast Alaska.

Spruce trees of all ages are susceptible to infection through contact with infected roots. Infected trees exhibit growth reduction or mortality, depending on age. Younger trees may be killed rapidly while older trees may persist in a moribund condition for many years. Trees with extensive root decay are prone to uprooting. Butt-decay of infected spruce trees typically extends eight feet up the stem.

Figure 20. A white spruce sapling killed by the root disease I. tomentosus.

In young growth managed stands, spruce seedlings planted within close proximity of infected stumps are highly susceptible to infection through contacts with infected roots. While individual mortality centers are typically small, coalescing centers can occupy several acres. Studies are currently underway to assess mortality in young growth stands and determine site factors that influence disease incidence and severity.

Levels of root disease can be manipulated by changes in species composition through stand conversion to non-susceptible (hardwood) species. Recognition of this root disease is important in managed stands where natural regeneration of white and Lutz spruce is limited and adequate restocking requires planting. Hardwood trees are resistant and may colonize infection centers.

Wildlife habitat, particularly for moose, may be enhanced by increased hardwood browse vegetation.

Annosus Root & Butt Rot

Heterobasidion annosum (Fr.) Bref.

Annosus commonly causes root and butt-rot in old-growth western hemlock and Sitka spruce forests in southeast Alaska (M245B, M244C). To date, *H. annosum* has not been documented in south-central or interior Alaska.

Elsewhere in the world, spores of the fungus are known to readily infect fresh stump surfaces, such as those found in clearcuts or thinned stands. Studies in managed stands in southeast Alaska, however, indicate limited stump infection and survival of the fungus. Thus, this disease poses minimal threat to young managed stands with this type of infection.

Reasons for the limited stump infection may be related to climate. High rainfall and low temperatures, common in Alaska's coastal forests, apparently hinder infection by spores.

Armillaria Root Disease

Armillaria spp.

Several species of Armillaria occur in the coastal forests of southeast Alaska, but in general, the species are less-aggressive, saprophytic decomposers that only kill trees when they are under some form of stress. Studies in young managed stands indicate that *Armillaria* sp. can colonize stumps, but will not successfully attack adjacent trees.

Several species of Armillaria occur in south-central and interior Alaska. Some species appear to be aggressive pathogens, causing root and butt rot of spruce and hardwood trees, while other species appear to be less-aggressive saprophytic fungi. Research is currently underway to determine the species of Armillaria and their impacts in the boreal forests.

DECLINES AND ABIOTIC FACTORS

Yellow-cedar Decline

Decline and mortality of yellow-cedar persists as one of the most spectacular forest problems in Alaska. Approximately 479,000 acres of decline have been mapped during aerial detection surveys. Concentrated mortality occurs in a wide band from western Chichagof and Baranof Islands to the Ketchikan area (M245B). Of the three administrative areas of the Tongass National Forest, the Stikine Area has the greatest concentration of cedar decline at just under 200,000 acres.

All research suggests that contagious organisms are not the primary cause for this extensive mortality. Some site factor, probably associated with poorly-drained anaerobic soils, appears to be responsible for initiating and continuing cedar decline. Two hypotheses have been proposed to explain the primary cause of death in yellow-cedar decline:

* Toxins are produced by decomposition in the wet, organic soils, or
* Shallow fine roots are damaged from freezing, associated with climatic warming and reduced insulating snowpack in the last century.

These hypotheses are developed in some detail (Hennon and Shaw 1994). Interestingly, considerable concentrations of newly-killed trees were evident in declining forests during 1996 and 1997, perhaps a response to the unusually prolonged cold temperatures with little snowpack that persisted during the previous two winters. Whatever the primary cause of this mysterious decline, all available information indicates that it is probably a naturally-occurring phenomenon. We initiated preliminary investigations this year in the areas of soils and hydrology with more detailed research planned for next year.

Research suggests that the total acreage of yellow-cedar decline has been increasing very gradually; the slow increase in area has been a result of the expansion of existing decline (<3 feet/year) into adjacent stands. Most stands contain trees that died up to 100 years ago (snags still standing), as well as recently killed cedars, dying cedars (with yellow, red, or thinning crowns), healthy cedars, and other tree species. Ground surveys show that 65% of the basal area of yellow-cedar is dead on this acreage. Other tree species are affected in different ways: on some sites they produce increased growth, presumably due to less competition, and on other sites they experience slowed growth and mortality because deteriorating site conditions (poor drainage). Species change to western hemlock and mountain hemlock and large increases in understory biomass accumulation for brushy species appear to be occurring in some stands where decline has been ongoing for up to a century.

The primary ecological effect of yellow-cedar decline is to alter stand structure (i.e., addition of numerous snags) and composition (i.e., yellow-cedar diminishing and other tree species becoming more numerous) that leads to eventual succession favoring other conifer species. The creation of numerous snags is probably not particularly beneficial to cavity-using animals because yellow-cedar wood is less susceptible to decay. Region-wide, this excessive mortality of yellow-cedar may lead to diminishing populations (but not extinction) of yellow-cedar, particularly when the poor regeneration of the species is considered.

The large acreage of dead yellow-cedar and the high value of its wood suggest opportunities for salvage. Cooperative studies with the Wrangell Ranger District, the Forest Products Laboratory in Madison, Wisconsin, Oregon State University, and State and Private Forestry are investigating the mill-recovery and wood properties of snags of yellow-cedar that have been dead for varying lengths of time. This work includes wood strength properties, durability (decay resistance), and heartwood chemistry.

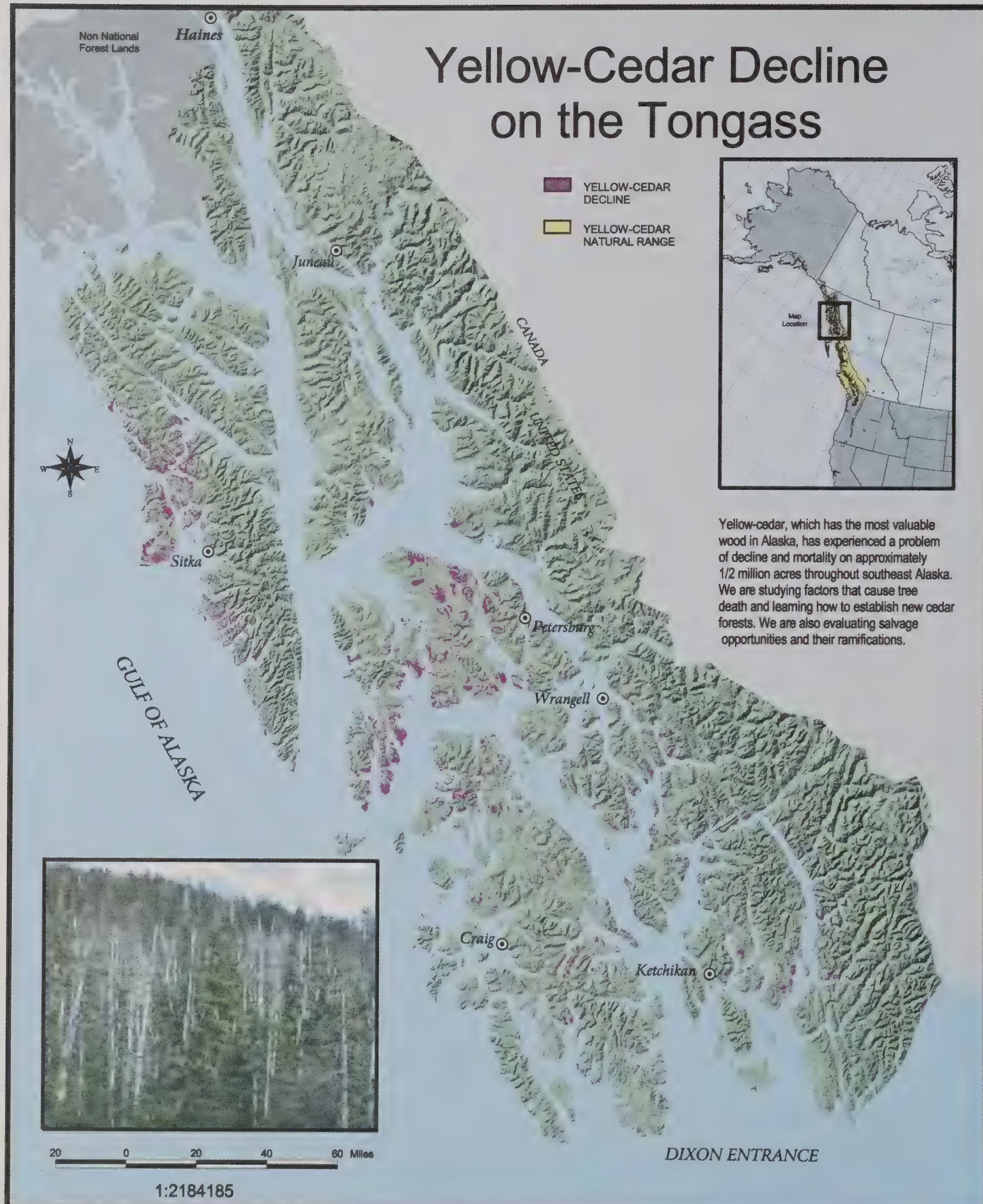
Little is known about wildlife use and dependency of yellow-cedar forests. In 1998, we initiated a study to evaluate birds' use of each of the snag classes as nesting or feeding habitat. In a companion study we are investigating the insect community on dead cedars; insects on some of the snags may be an important prey source for insectivorous birds.

Table 4. Acreage affected by yellow-cedar decline in southeast Alaska in 1998.

	Acres
NATIONAL FOREST LAND	***434,919***
Chatham Area Total	***114,423***
Juneau Ranger District	865
Hoonah Ranger District	1,058
Sitka Ranger District	
Chichagof I	32,220
Baranof I	48,098
Kruzof I	26,763
Sub-total	107,081
Admiralty Island Nat'l Mon. Wilderness	5,419
Stikine Area Total	***196,136***
Petersburg Ranger District	
Kupreanof I	79,961
Kuiu I	62,245
Mitkof I	5,034
Woewodski I	2,157
Mainland	6,710
Sub-total	156,107
Wrangell Ranger District	
Etolin I	16,979
Wrangell I	8,669
Zarembo I	3,778
Woronofski I	441
Mainland	10,162
Sub-total	40,029
Ketchikan Area Total	***124,360***
Craig Ranger District	
Prince of Wales I	27,493
Dall I and Long I	901
Sub-total	28,394
Ketchikan Ranger District	
Revillagigedo I	13,508
Gravina I	809
Mainland	13,749
Sub-total	28,067

	Acres
Ketchikan Area (continued)	
Thorne Bay Ranger District	
Prince of Wales I	28,628
Kosciusko I	11,836
Heceta I	1,044
Sub-total	41,507
Misty Fjords Nat'l Mon. Wilderness	
Revillagigedo I	8,918
Mainland	17,474
Sub-total	26,392
NATIVE LAND	***21,822***
Prince of Wales I	10,182
Dall and Long I	675
Kupreanof I	5,061
Baranof and Chichagof I	1,124
Ketchikan area	3,339
Annette I	984
Kuiu I	457
STATE & PRIVATE LAND	***22,015***
Admiralty I	9
Baranof I	3,085
Dall and Long I	62
Chichagof I	605
Gravina I	1,317
Mitkof I	1,497
Kosciusko I	551
Kuiu I	741
Kupreanof I	1,395
Prince of Wales I	4,624
Wrangell area	1,809
Revillagigedo	3,323
Kruzof I	299
Other Mainland	2,698
Other Federal	***323***
Baranof I	323
Total Land Affected	***479,079****

*Acreage by ownership was tabulated using Alaska land status data from ADNR. In prior years a different ownership layer was used to tabulate this information. Other changes in acreage figures are due to a change in the resource, refined sketch-mapping or changes in GIS techniques.


Yellow-Cedar Decline on the Tongass
YELLOW-CEDAR DECLINE
YELLOW-CEDAR NATURAL RANGE
Map Location
Yellow-cedar, which has the most valuable wood in Alaska, has experienced a problem of decline and mortality on approximately 1/2 million acres throughout southeast Alaska. We are studying factors that cause tree death and learning how to establish new cedar forests. We are also evaluating salvage opportunities and their ramifications.
Non National Forest Lands
Haines
Juneau
CANADA
UNITED STATES
Sitka
Petersburg
Wrangell
GULF OF ALASKA
Craig
Ketchikan
DIXON ENTRANCE
N
S
E
W
20 0 20 40 60 Miles
1:2184185

Water Damage

Flood damage was noted on over 800 acres in scattered locations across the state. Approximately 150 acres of conifer stands were affected in southeast Alaska.

In south-central and interior Alaska, flood damage to mixed conifer and hardwood stands adjacent to rivers occurred on approximately 680 acres. Included in this figure is an area of volcanic activity in the Copper River valley which is flooding approximately 100 acres with hot mud.

Windthrow

In 1997, there were approximately 700 acres of windthrow in the Chatham Area, Hoonah Sound, Chichagof Island (M245B). Another 600 acres occurred in Glacier Bay National Park between Harbor Point and Icy Point, west of the Fairweather Mountain Range (245A). Both windthrow areas were in the spruce/hemlock forest type. Since spruce beetles prefer windthrown spruce as habitat, there is a possibility that an infestation will start in these areas; the extent will be determined by weather. During the 1998 survey, no spruce beetle infestations were detected in these areas. An additional 150 acres of windthrow were detected.

Hemlock Fluting

Deeply incised grooves and ridges extending vertically along boles of western hemlock characterize hemlock fluting. Fluting is distinguished from other characteristics on tree boles, such as old callusing wounds, in that fluting extends near or into the tree crown and fluted trees have more than one groove. Bole fluting is common on western hemlock in many areas of southeast Alaska. This condition reduces the value of hemlock logs because they yield less sawlog volume and bark is contained in some of the wood. The cause of fluting is not completely known, but associated factors include: increased wind-firmness of fluted trees, shallow soils, and a triggering mechanism during growth release (e.g., some stand management treatments). The asymmetrical radial growth appears to be caused by unequal distribution of carbohydrates due to the presence of dead branches. Researchers have documented the development of fluting in young hemlock stands that regenerated following clearcut harvesting or other disturbance. After several centuries, fluting sometimes is no longer outwardly visible in trees because branch scars have healed over and fluting patterns have been engulfed within the stem.

Bole fluting has important economic impact, but may have little ecological consequence beyond adding to windfirmness. The deep folds on fluted stems of western hemlock may be important habitat for some arthropods and the birds that feed upon them (e.g., winter wren).

Figure 21. Hemlock Fluting
Branches disrupt the vertical flow of carbohydrate in the stem causing annual rings to become asymmetrical. Flutes originate beneath decadent branches and extend downward, forming long grooves where other branches are intersected.
(Figure and caption from Julin, K.R.; Farr, W.A. 1989. Stem Fluting of Western Hemlock in Southeast Alaska).

STATUS OF ANIMAL DAMAGE

Porcupine

Erethizon dorsatum

Porcupines cause severe damage to Sitka spruce and western hemlock trees in numerous local areas of southeast Alaska. An extensive survey has documented the level of porcupine damage in young-growth stands. Feeding injuries to trees are confined to the known distribution of porcupine. Damage is especially serious on Mitkof Island in southeast Alaska. Other damage has been noted at Thomas Bay, Cleveland Peninsula, Bradfield Canal, Anita Bay and other areas of Etolin Island, Douglas Island, and the Juneau area (M245B). Shore pine near Haines has been damaged the last few years (M244C). Porcupines also damage trees throughout interior Alaska. Bark beetles, including *Ips* spp., have been found infesting the damaged trees.

In southeast Alaska, the feeding behavior of porcupines changes as forests develop and trees become larger and older. Porcupines climb smaller trees and kill or cause topkill by removing bark along the entire bole, or the bole near the top of the tree. As trees become larger, around 40-50 years old, most of the damage is in the form of basal wounding. Most of these larger trees are not killed, but the large basal scars allow fungi to enter the bole and begin to cause wood decay.

The primary ecological consequences of porcupine feeding are: (1) to provide greater diversity of structure and vegetation in young, even-aged conifer stands through mortality and (2) to provide greater levels of heart rot decay by wounding older trees. This latter effect can alter mortality patterns in old forests as trees may often die through bole breakage.

Bear

Ursus arctos
Ursus americanus

Yellow-cedar trees were wounded in the spring by brown bears on Baranof and Chichagof Islands (M245B). Brown bears rip the bark away from the lower boles of these trees, apparently to lick the sweet cambium. The majority of yellow-cedar trees in some stands have basal wounds from bear feeding. Other tree species in southeast Alaska are unaffected. Black bears caused injury to the lower boles of white and Lutz spruce and occasionally aspen in the lowland forests of the Kenai Peninsula (213B). Trees with old scars have associated columns of wood decay that will limit the value of their butt logs.

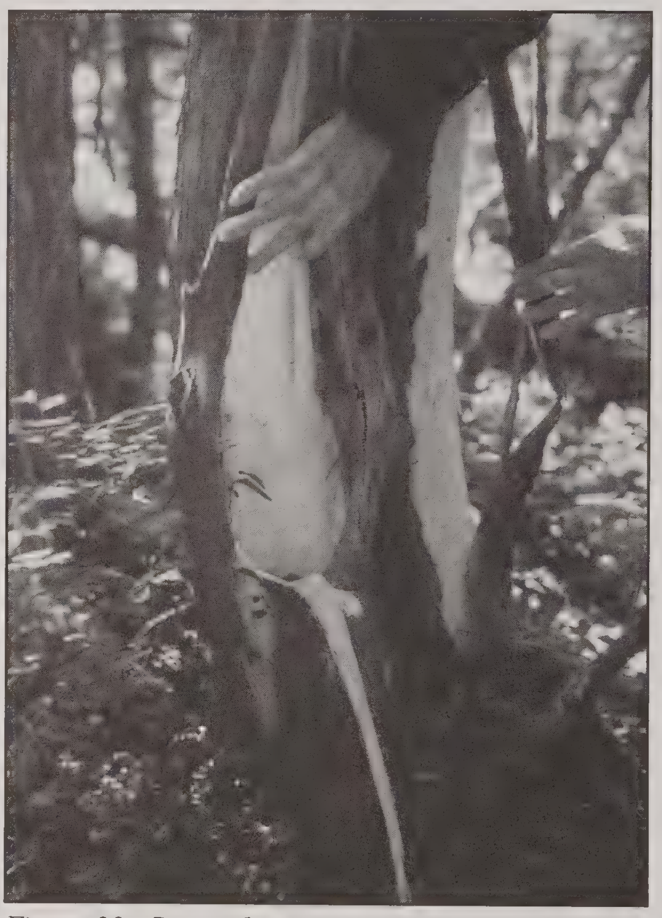


Figure 22. Recent bear scar on yellow-cedar tree.

Moose

Alces alces

At many locations across south-central and interior Alaska, moose cause severe damage to hardwood species by repeatedly browsing stems. In the winter, moose congregate in areas containing young hardwoods, often consuming the new growth on the same trees year after year. Snow cover typically protects stems less than 20 inches tall, while stems greater than 12 feet tall are generally out of reach and escape damage. Heavy, repeated browsing results in stunted malformed stems, branch wounds, and mortality. Wood decay fungi penetrate branch wounds resulting in a high incidence of stain and decay in browsed stems.

APPENDICES

APPENDIX A

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) has been described as a "systems approach to alter pest damage to acceptable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications, and when necessary and appropriate, chemical pesticides." Current IPM activities in Region 10 include:

- Participation in a cooperative effort with the Alaska Cooperative Extension (ACE) to provide pest management information to Alaska residents. The program, which includes education, research and survey activities, also provides integrated pest management information concerning urban forestry as well as garden and greenhouse pests. The program is educational in nature and provides the public with a means to learn about pest management in an informal and accessible manner. 1998 IPM Technicians were located in Fairbanks, Delta, Palmer, Anchorage, Soldotna, and Juneau. The Anchorage office had two full time technicians; the remaining locations had one seasonal IPM Technician from May through the end of September. The total recorded client contacts reached well over 5,000; which were more than 50% of all contacts made by Cooperative Extension. The 1998 Technicians conducted more than 30 workshops and more than a dozen media contacts (newspaper articles, television and radio "spots"). In addition, there is now an IPM Technician Home Page <http://www.go2net.org/pest>. This home-page describes the program and has a wealth of IPM information pertinent to Alaska.

  In an effort to expand the outreach program, ACE and FHP continued funding the Alaska Forestry IPM Technician position. This position was established in 1995 and is a full-time, 12-month position. This position has allowed us to meet the needs of Alaskans with more specific forest pest and woodlot management issues and concerns in south-central Alaska. We anticipate the continuation of this position next year.

- Two thinning studies aimed at reducing spruce beetle-caused tree mortality have been established on the Kenai Peninsula. The first study was established in 1989 in a mature (148 yr.-old Lutz spruce) stand in the Granite Creek area. The second study was initiated in 1995 in a younger 70-yr.-old Lutz spruce stand near Tustumena Lake. The objectives of these studies are to determine efficacy of thinning from below, pruning, and fertilization in reducing spruce beetle caused tree mortality. Changes in understory vegetation as a result of treatments (e.g., logging and fertilization) and those which occur in untreated stands are also being monitored. Preliminary results have indicated a significant reduction in beetle-caused tree mortality in thinned vs. unthinned stands in the Granite Creek area where beetle populations are moderate. The Tustumena Lake area experienced a heavy, intense beetle flight in 1997 and 1998. After the 1997 flight, approximately 40% of the trees in the unthinned plots were attacked vs. 10% of the trees in the treated plots. This treatment effect, however, did not last through the 1998 beetle flight. An additional 12% of the trees in the unthinned plots came under attack whereas an additional 40% of the trees in the treated plots were attacked. It was noted, however, that the majority of the new attacks in the thinned plots in 1998 were "wet" attacks. We will not know until next year whether these attacks were successful or not.

- In S.L. Wood's 1982 Monograph [The Bark and Ambrosia Beetles of North and Central America], there is a reference that *Ips perturbatus* is very similar to *Ips typographus*, commonly referred to as the European spruce beetle. The specific semio-chemicals of *I. perturbatus* are currently being identified. Past pheromone trapping, using cis-verbenol and racemic Ipsdienol, have resulted in heavy trap catches. *I. typographus* is trapped efficiently in Europe utilizing cis-verbenol, racemic Ipsdienol, and a heavy dose (1400 mg.) of methyl butenol

  In the spring/summer of 1998, we compared *I. perturbatus* trap catches as related to four pheromone treatments: (1) Check, (2) cis-verb + Ipsdienol, (3) Ipslure (cis-verb + Ipsdienol + methyl butenol, and (4) Ecolure (same as treatment #3).

Preliminary results showed significant differences between pheromone baited traps and checks, but no differences between pheromone treatments. Preliminary results are as follows: Check-av. 75 beetles/trap; Ipsdienol + cis-verb—av. 329 beetles/trap; Ipslure—394 beetles/trap; and Ecolure—265 beetles/trap. Based on these results, it appears that the *Ips* species distinctions are correct.

- In 1998, we entered a Cooperative Agreement with Dr. Steve Seybold of the Univ. of Nevada/Reno and the PSW Station. The project was to identify both the aggregant and anti-aggregants of *I. perturbatus*. Previously, we have used cis-verbenol and Ipsdienol Pherotech bubble caps and have captured large numbers of adults. However, the pheromone complex has never been examined.

  Lutz spruce bolts infested with *I. perturbatus* were shipped to Dr. Seybold's lab. Insects were reared and volatiles extracted from feeding adults. Preliminary findings based on gas chromatograph and mass spectrometry have identified cis- and trans-verbenol, ipsenol, and ipsdienol. Stereochemistry of the compounds is underway. Final report/publication will be out within a year.

- In 1996, we saw an increase in *Ips perturbatus* activity in recently salvaged logged stands of Lutz spruce on the Kenai Peninsula. *Ips* activity in south-central Alaska has been, up to now, a "rare" occurrence. It's activities are more commonly associated with interior Alaska white spruce. *Ips* attacked and killed approximated 11.5% of the standing residual spruce in 1996. This escalated in 1997; more than 32% of the remaining residual spruce were killed. Thus, in a 2-yr. period, close to 43% of the residual spruce were attacked and killed.

  Based on previous success using cis-verbenol and Ipsdienol in trapping large numbers of dispersing *I. perturbatus*, we decided to try a trap-out study in the spring of 1998. Six circular 1-acre plots were established; three randomly treated with seven baited pheromone traps each [3 in the center and 1 trap/cardinal direction on outer edge of plot]; and three plots left as untreated checks. Only 10,028 beetles were caught in the 21 traps; much fewer than previously caught. This, to us, indicated that the *Ips* population was declining.

  The results of the trap-out confirm our suspicions of a collapsing *Ips* population and are as follows: The pheromone treated areas had an average of 2.3% newly attacked trees per plot; the untreated check plots sustained and average of 3.6% newly attacked trees per plot. 50% of the newly attacked spruce in the treated areas were within 10-15' of the baited traps and may have occurred as a result of spill-over. It appears that population pressure in the study area was too low to determine if the trap-out procedure would work.

- Yellow-cedar wood has been devalued because of blue-staining. Some evidence suggests that insects are involved in introducing a blue-staining fungus. Wood boring insect tunnels were found in association with the blue stained areas. Blue-stained, borer-infested logs were transported back to our lab and wood wasps were reared from them in 1998. Since these wood wasps are believed to have only a one year life cycle, many of them can be reared from infested logs and isolations can be made from the sac at the base of the ovipositor (of the females). It can then be determined if blue-stain fungi are being inoculated into trees at the time of egg laying. Wood wasps in other tree species are known to introduce decay fungi.

- The spread and intensification of hemlock dwarf mistletoe is currently under study in even-aged stands, stands that have received different selective harvest treatments, and stands that experienced extensive wind damage 110 years ago. Plots within these stands have been used to quantify the short, medium, and long-term effects of the disease under different selective harvesting strategies. Results show a substantial difference by stand management. Impact of the disease is light to absent in later developmental stages of single-cohort stands but can be severe under some forms of selective harvesting. This indicates a remarkable range of disease severity that can be related to simple measures of inoculum load at the time of harvest. Distances and intensities of spread are being determined to provide information so that managers can design appropriate harvesting scenarios in relation to expected disease levels.

APPENDIX B

SUBMITTING INSECTS AND DISEASES FOR IDENTIFICATION

The following procedures for the collection and shipment of specimens should be used for submitting samples to specialists:

I. Specimen collection:

1. Adequate material should be collected
2. Adequate information should be noted, including the following:
    a. Location of collection
    b. When collected
    c. Who collected the specimen
    d. Host description (species, age, condition, # of affected plants)
    e. Description of area (e.g., old or young forest, bog, urban);
    f. Unusual conditions (e.g., frost, poor soil drainage, misapplication of fertilizers or pesticides?).
3. Personal opinion of the cause of the problem is very helpful.

II. Shipment of specimens:

1. General: Pack specimens in such a manner to protect against breakage.
2. Insects: If sent through the mail, pack so that they withstand rough treatment.
    a. Larvae and other soft-bodied insects should be shipped in small screw-top vials or bottles containing at least 70% isopropyl (rubbing) alcohol. Make certain the bottles are sealed well. Include in each vial adequate information, or a code, relating the sample to the written description and information. Labels inserted in the vial should be written on with pencil or India ink. Do not use a ballpoint pen, as the ink is not permanent.
    b. Pupae and hard-bodied insects may be shipped either in alcohol or in small boxes. Specimens should be placed between layers of tissue paper in the shipping boxes. Pack carefully and make certain that there is very little movement of material within the box. Do not pack insects in cotton.
3. Needle or foliage diseases: Do not ship in plastic bags. Sprinkle lightly with water before wrapping in newspaper. Pack carefully and make sure that there is very little movement of material within the box. Include the above collection information. For spruce and other conifers, include a description of whether current year's-needles, last-year's needles, or old-needles are attacked.
4. Mushrooms and conks (bracket fungi): Do not ship in plastic bags. Either pack and ship immediately, or first air dry and then pack. To pack, wrap specimens in dry newspaper and pack into a shipping box with more newspaper. If on wood, include some of the decayed wood. Be sure to include all collection information.

III. Shipping:

1. Ship as quickly as possible, especially if specimens are fresh and not air-dried. If samples cannot be shipped rapidly, then store in a refrigerator.
2. Include address inside shipping box.
3. Mark on outside: "Fragile: Insect-disease specimens enclosed. For scientific purposes only. No commercial value."

APPENDIX C

BIOLOGICAL EVALUATIONS, TECHNICAL REPORTS, AND PUBLICATIONS

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APPENDIX C

Trummer, L.M. 1996. Modeling hemlock dwarf mistletoe *(Arceuthobium tsugense subsp. tsugense)* spread and intensification in mature uneven-aged forests in southeast Alaska. M.S. Thesis. Oregon State University, Corvallis, OR. 77p.

Trummer, L.M.; Hennon, P.E.; Hansen, E.M.; Muir, P. 1998. Modeling the incidence and severity of hemlock dwarf mistletoe in 110-year old wind-disturbed forests of southeast Alaska. Can. J. For. Res. In press. Accepted for publication 7/24/98.

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APPENDIX D

ECOMAP SECTION DESCRIPTIONS

The Sections included in this report are briefly described below, along with descriptions of the appropriate Domains, Divisions, and Provinces. The prefix "M" attached to codes represents mountainous Sections where soil and vegetational zones are present. Fire frequency classification at the section level is adopted from Gallant et al (1995). The classification categories are based on frequency of lightning fires and are as follows: very low (less than 1 fire/year), low (1-5 fires/year), common (6-10 fires/year), very common (11-20 fires/year), and frequent (more than 20 fires/year). Typical insect damage are noted for each Section.

100 Polar Domain: Climate is controlled primarily by polar air masses. Winters are severe and total annual precipitation is small.

120 Arctic Division: Along the northern fringes of North America, with very short, cool summers and long, severe winters. Soil derived from mechanical breakup of rock with little to no chemical alteration. Permafrost layer can be up to 1000 feet in depth, with seasonal thaw reaching only 4 - 24 inches below the surface. Vegetation is dominated by grasses, sedges, lichens, and willow shrubs. Forest vegetation occurs only in the most southern areas.

125 Brooks Range Tundra Province: The Brooks Range is a northern extension of the Rocky Mountains. The Province is characterized rugged, deeply dissected mountains carved from uplifted and folded sedimentary rock, broad u-shaped valleys, and morainal topography of rolling plateaus and foothills.

M125A Brooks Range Mountain Section: The arctic climate and unstable slopes limit vegetation to dwarf scrub willow and lichen throughout most of the region. Sparse forest vegetation is found along rivers and flood plains. White spruce, birch, aspen, black spruce and balsam poplar occur in the most southern portions of the Section. Wildfires are fairly common. Defoliators, bark beetles and needle rust have been noted.

130 Subarctic Division: Climate has great seasonal range. Permafrost prevails under large areas. Despite low temperatures and long winters, the valleys were not glaciated during the Pleistocene. Boreal forests and open woodlands with abundant lichen predominate.

131 Yukon Intermontane Taiga Province: Series of broad valleys covered with alluvial deposits and low mountains and hills. The Province lies between the Brooks and Alaska Ranges, with Yukon, Tanana, Koyukuk, and upper Kuskokwim rivers providing drainage. The climate is semi-arid. Forest vegetation includes white spruce and hardwoods along river bottoms and uplands near rivers, and black spruce dominates on uplands.

131A Yukon Bottomlands Section: Closed forests of spruce, birch, and aspen on better drained sites, open black spruce forests on wetlands interspersed with willow thickets. Wetlands occupy much of the land cover, and permafrost is wide spread but discontinuous. Wildfire is frequent. Insect damage reported in the past includes spruce, larch, aspen, and willow defoliators along with bark beetles.

131B Kuskokwim Colluvial Plain Section: Forest vegetation includes spruce-poplar forests, open black spruce woodlands, and flood plain thickets of willow and alder. Wildfire is very common to frequent and river flooding frequent in the spring. Surveys can hampered by poor visibility due to smoke from wildfires. Insect damage includes larch, aspen, and willow defoliation, and *Ips*.

M131A Upper Kobuk-Koyukuk Section: Forests of white and black spruce, birch, and aspen occur on well drained sites. Black spruce and tamarack are associated with wet sites. Wildfires are common. Larch sawfly has been reported in this section.

M131B Nulato Hills Section: Most of the area supports alpine tundra, but spruce-birch-aspen forests occur at lower elevations. Wildfires are frequent. Bark beetles have been active here.

M131C Kuskokwim Mountains Section: Open black spruce forests are abundant, alpine tundra cover the hills. White spruce - paper birch communities predominate on lower hillslopes. Wildfires are frequent. Defoliators and bark beetles have been observed.

M131D Nushagak-Lime Hills Section: Alpine tundra dominates the rounded to flat topped ridges, and spruce, aspen, and birch prevail in the broad and gentle sloping valleys. Wildfires are frequent. Bark beetles and defoliators have been reported in the past.

135 Alaska Range Taiga Province: This Province is composed of a broad basin surrounded by steep, rugged mountains of the Alaska, Wrangell, and Chugach Ranges. Rivers originate in valley glaciers at high elevations and are often swift and braided with heavy sediment loads. The Copper River is the primary drainage. Forest vegetation includes open black spruce woodlands, with white spruce occurring on better drained soils and along riparian zones in the mountainous Sections.

135A Copper River Basin Section: The basin consists of rolling to hilly moraines and nearly level alluvial plains that occupy the site of a Pleistocene glacial lake. Elevation is 1000 feet or greater. Open black spruce forests are interspersed with large areas of brushy tundra. White spruce occurs on south-facing gravelly moraines. Cottonwood occurs on large flood plains. Fire occurrence is low, and flooding is an important natural disturbance. Damage can include bark beetles, defoliation, and flooding.

M135A Northern Chugach Range Section: Forest vegetation is limited to spruce and hardwoods along the larger rivers. Snow and rock avalanches are common, wildfire occurrence is very low. Damage from bark beetles along river drainages has been reported.

M135B Wrangell Mountain Section: This section is dominated by steep rugged mountains of volcanic origin that have been covered by ice fields and glaciers. Most slopes lack vegetation. Forests of white spruce, birch or aspen occur on broad ridges, valleys, and hilly moraines at lower elevations. Willow and alder are important shrubs. Wildfire occurrence is very low. Defoliators and bark beetles can be active.

M135C Alaska Range Section: Steep mountain ridges are separated by broad valleys, where spruce and hardwood forests occur along riparian zones. Snow avalanches occur frequently, but wildfire occurrence is low. Insect damage reported include bark beetles and defoliation.

139 Upper Yukon Taiga Province: The Province contains the Yukon Flats Section, a flat marshy basin, and the surrounding the rounded mountains and hills. The climate is extreme with large seasonal temperature ranges. Winters are long and cold, and the short summers are hot and dry; some areas at higher elevations are moisture deficit in summer. Wildfire is very common. Permafrost is semi-continuous, and highly subject to alteration from disturbance.

139A Yukon Flats Section: The flat, marshy basin has numerous braided, meandering streams, thaw and oxbow lakes. The lowest parts of the flood plains are poorly drained, but the natural river levees are better drained. Permafrost is present except for beneath rivers and large lakes. White spruce is found on well drained sites, black spruce where drainage is poor. Aspen and poplar occur on flood plains, willow and alder are found in the understory and in the tall scrub communities. Flooding and wildfire are both common. Bark beetles and defoliators can occur.

M139A Ray Mountain Section: Low mountains and hills to the west of the flats. Permafrost, surface water, hillslope, and wildfire interactions result in a complex plant community mosaic. Forests of white spruce, birch, and aspen dominate the lower slopes in the south and south-facing slopes in the north. Black spruce occurs at higher elevations, on north-facing slopes, and all but steep south-facing slopes. Wildfire is very common to frequent. Damage from insects can include bark beetles and defoliators of both conifers and hardwoods.

M139B Ogilvie Mountain Section: Flat-topped hills eroded from former plains and pediment slopes. Karst topography is common. Forest communities occur on lower hillslopes and valleys. Permafrost is common. White spruce grow in well drained valleys and protected sites. Aspen and poplar are on well drained warmer sites. Mixed forests on poorly drained sites are dominated by black spruce and birch. Wildfire is less common. Defoliators and bark beetles can occur.

M139C Dawson Range Section: This section has steeper rounded ridges with some rugged peaks. Forest vegetation occurs at lower elevations. Open spruce forests are domi-

nated with white spruce, with black spruce sometimes co-dominating. Birch and aspen also occur. Wildfire is very common. Damage reported include bark beetles, larch sawfly, and hardwood defoliation.

200 Humid Temperate Domain: Climate is influenced by both marine and polar air masses.

210 Warm Continental Division: Distinct seasons with snowy winters and warm summers. Needle-leaf forests are common.

213 Alaska Mixed Forest Province: This Province has smooth and irregular plains and surrounded by high mountains. It is centered around Cook Inlet in south-central Alaska. Climate is transitional between polar and maritime. This is reflected in the range of forest cover types: spruce - hemlock to mixed hardwoods. Permafrost is rare.

213A Bristol Bay Lowlands Section: The rolling terrain developed from morainal deposits. Soil texture is coarse near the mountains, becoming finer near the coast. Dwarf scrub communities dominate, but broadleaf and mixed forest stands occur along flood plains. Birch, poplar, white spruce, willow and alder are present. Wildfire occurrence is low. Defoliators are occasional.

213B Cook Inlet Lowlands Section: This broad basin has been shaped by many glacial events. Spruce/hardwood forests are most widespread across the level to rolling plains. Wildfire occurrence from lightning strikes is low, but fires resulting from human activity are very common. This area is heavily populated and has been influenced by agriculture, urban development, petroleum extraction, and human recreation. Damage from bark beetles, defoliators, foliar diseases, and flooding are common. Exotic pests are reported here more than anywhere else in Alaska.

M213A Northern Aleutian Range Section: This section contains steep, rugged mountains of volcanic origin. Large lakes occupy the glaciated valleys. Open spruce forests occur in well drained sites in some valleys and lower hill slopes. Avalanches are common, wildfire occurrence is low. Bark beetles have impacted much of the spruce forests. Cottonwood defoliators can also occur.

M213B Kenai Mountains Section: This Section is dominated by the Kenai and western Chugach mountains. The area has been heavily glaciated. Forest vegetation occurs from mid to low elevations and along rivers and coast lines. Avalanches and flooding are important disturbance events. Wildfire occurrence from lightning strikes is low, but fires resulting from human activity are common. Past land clearing activities, including fire, have influenced the present landscape. Bark beetles and defoliators occur.

240 Marine Division: This zone receives abundant rainfall from maritime air masses. Temperature ranges are narrow due to the marine influence.

244 Pacific Coastal Icefields Province: This Province stretches from the Coast Mountains of southeast Alaska through the St. Elias mountains up to the Chugach-Kenai Mountains. Glaciers and icefields cover the higher portions of the mountains. Rock, ice, and alpine vegetation prevails. The lower elevations support some forests of hemlock and Sitka spruce. Willows and black cottonwood are found infrequently along the glacial river beds.

M244A Chugach Range Section: Alpine vegetation dominates. Forest vegetation is confined to the lowest side-slopes and river bottoms. Hemlock, spruce and cottonwood are predominant. Snow and rock avalanches are common, and flooding events are significant. Wildfire occurrence is very low. Damage from spruce beetle, conifer defoliators, and flooding has been reported.

M244B St. Elias Range Section: Alpine tundra dominates, with forest vegetation confined to river drainages, mostly spruce and hardwoods. Avalanches and flooding are major natural disturbances. Wildfire occurrence is very low. Damage from spruce beetles and defoliators can occur.

M244C Boundary Range Section: This section straddles the international boundary with Canada. Forest vegetation of hemlock, spruce, and cottonwood only occurs along river corridors within mountain passes. Snow avalanches and landslides create large-scale disturbances. Wildfire occurrence is very low. Damage can include

defoliators, flooding, spruce beetle, windthrow, and porcupine feeding.

245 Pacific Gulf Coast Forest Province: This Province consists of fjords and mountainous terrain. The Province has the mildest winters in Alaska and abundant precipitation. Hemlock, Sitka spruce, and cedar dominate the coastal rainforests.

245A Gulf of Alaska Forelands Section: The coastal lowlands feature alluvial fans, uplifted mudflats, moraine deposits, and river deltas. Spruce-hemlock forests occur on well-drained sites, whereas alder, willow, and birch dominate wetland areas, with cottonwood occurring along major river channels. Glacial outburst floods and earthquakes causing uplift and subsidence are significant disturbances. Strong winds also influence forest vegetation structure. Wildfire is rare. Damage can include black-headed budworm, spruce beetle, and flooding.

M245A Gulf of Alaska Fjordlands Section: Islands and headlands with steep cliffs from eroded bedrock characterize this section. They support Sitka spruce and hemlock forests. Landslides and avalanches are common and outer islands are subject to intense winds from winter storms. Wildfire is rare. Damage reported includes windthrow, flooding, cottonwood defoliation, conifer defoliation, landslide, spruce beetle, and thinning spruce crowns.

M245B Alexander Archipelago Section: The rugged islands and mountains of southeast Alaska are dominated by rainforests of hemlock, Sitka spruce, and cedar. Wildfires only occur during drought. Landslides and avalanches are frequent in the steeper terrain. The outer islands are subject to extreme winds from winter storms, and so windthrow is common. Other damage includes spruce beetle, conifer defoliation, porcupine damage, and flooding.

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APPENDIX E

WORLD WIDE WEB LINKS

Forest insect and disease survey information and general forest health information:

http://www.dnr.state.ak.us/forestry
An Alaska Department of Natural Resources, Division of Forestry home page was assembled in late 1996 for the fire and resource management programs. The site is currently under development but information is available on several of Forestry's programs, including forest health and forest insect surveys. Information will be updated as personnel and funding permit. Users may check the site for information relating to forest health. A link is provided on the home page for accessing forest health and insect survey information and to send an e-mail message. The URL for this insect and disease link is
http://www.dnr.state.ak.us/forestry/res_faq.htm.

http://www.fs.fed.us/r10/spf/fhpr10.htm
USFS, State & Private Forestry, Forest Health Protection site for Alaska with information on Alaskan insects & diseases, bibliography listing, and links to other Forest Health sites. The section presents a program overview, personnel information, current forest insect and disease conditions throughout the state, forest insect and disease biology, control, impacts, Sbexpert software and other Forest Health issues. This Home Page is periodically updated and is a good source of information on Alaska Forest Health issues.

http://nsdi.usgs.gov/nsdi/
The USGS node of the National Geospatial Data Clearinghouse is a component of the National Spatial Data Infrastructure (NSDI). The Clearinghouse provides a pathway to find information about geospatial or spatially referenced data available from USGS. The information is in the form of metadata. Metadata or "data about data" describe the content, quality, condition, and other characteristics of data. Metadata are used to organize and maintain investments in data, to provide information to data catalogs and clearinghouses, and to aid data transfers. This site is maintained by the USGS in cooperation with the U.S. Federal Geographic Data Committee (FGDC).
AGDC Entry Point to Geospatial Data Clearinghouse
http://agdc.usgs.gov/AGDCgateway.html

http://www.fs.fed.us/r6/nr/fid/fidls/fidl127.htm
An USDA Forest Service Oregon/Washington Home-page. This is a link to the FIDL publication #127 on the Spruce Bark Beetle

http://www.go2net.org/pest
There is now an Integrated Pest Management Technician Home-page. This home-page describes the program and has a wealth of IPM information pertinent to Alaska.

http://www.state.ak.us/local/akpages/FISH.GAME/habitat/geninfo/forestry/INFEST/infesthome.htm
The Interagency Forest Ecology Study Team (INFEST) home-page. This site has ecological information pertaining to wildlife and forests, spruce bark beetle, basic silvics, and other Alaska ecosystem considerations.

APPENDIX F

INFORMATION AVAILABLE FROM STATEWIDE AERIAL SURVEYS

Each year, forest damage surveys are conducted over approximately 30 million acres. This annual survey is a cooperative effort between U.S. Forest Service, State and Private Forestry, Forest Health Protection (S&PF/FHP) and State of Alaska, Department of Natural Resources, Division of Forestry (AKDNR/DOF) entomologists to assess general forest conditions on Alaska's 129 million acres of forested area. About 25% of Alaska's forested area is covered each summer using fixed-wing aircraft and trained observers to prepare a set of sketch-maps depicting the extent (polygons) of various types of forest damage including recent bark beetle mortality, various hardwood and conifer defoliation, and abiotic damage such as yellow-cedar decline. A number of other damage types are noted including flooding, wind damage, and landslide areas during the survey. The extent of many significant forest tree diseases, such as stem and root decays, are not estimated from aerial surveys since this damage is not visible from aerial surveys as compared to the pronounced red topped crowns of bark beetle-killed trees.

In this way, forest damage information is sketched on 1:250,000 scale USGS quadrangle maps at a relatively small scale. For example, at this scale one inch would equal approximately 8 miles distance on the ground. When cooperators request specialized surveys, larger scale maps are sometimes used for specific areas to provide more detailed assessments. Due to the short Alaska summers, long distances required, high airplane rental costs, and the short time frame when the common pest damage signs and tree symptoms are most evident (i.e., usually only during July and August), sketch-mappers must strike a balance to efficiently cover the highest priority areas with available personnel schedules and funding.

Prior to the annual statewide forest conditions survey, letters are sent to various state and federal agency and other landowner partners for survey nominations. The federal and state entomologists decide which areas are highest priority from the nominations in addition to selecting areas where several years data are collected to establish trends from the year-to-year mapping efforts. In this way, general trend information is assembled from the sketch-maps for the most significant pests and damage encountered for this annual Conditions Report. The sketch-map information is also digitized and put into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by users.

Information listed in this Appendix and is a sample of the types of products that can be prepared from the statewide surveys and GIS databases that are available. Due to the relatively high cost of mass-producing hard copy materials from the survey data, including colored maps, a number of other map products that are available have not been included with this report. In addition, maps which show the general extent of forest insect damage from 1998 and previous statewide aerial surveys, landowner boundaries, and other types of map and digital data can be made available in various formats depending on the resources available to the user:

Submit data and map information requests to:

Roger Burnside, Entomologist
State of Alaska, Department of Natural Resources, Division of Forestry
3601 C Street, Suite 1034
Anchorage, AK 99503-5937
phone: (907) 269-8460
fax: (907) 561-6659
E-mail: roger_burnside@dnr.state.ak.us

Kathy Matthews, Biotechnician
USDA Forest Service, State and Private Forestry, Forest Health Protection
3301 C Street, Suite 522
Anchorage, AK 99503-3956
phone: (907) 271-2574
fax: (907) 271-2897
E-mail: kmatthews/r10_chugach@fs.fed.us

APPENDIX F

Map information included in this report: "Forest Insect And Disease Conditions In Alaska-1998"

1. **General Forest Pests Activity 1998 Aerial Detection Survey;** 11x17 in. format, depicting spruce beetle, spruce budworm, larch sawfly, and spruce needle aphid activity (color; showing enhanced representation of damage areas).

2. **1998 Alaska Forest Damage Surveys Flight Lines and Major Alaska Landownership Blocks** (includes table listing acres surveyed by landowner based on flight lines flown for the 1998 aerial surveys).

3. **Kenai Peninsula Region Spruce Beetle Activity 1993-1998,** 8 1/2 x 11 in. format, depicting sequential year-by-year spruce beetle activity in south-central Alaska, including the Kenai Peninsula, Cook Inlet area to Anchorage & Talkeetna (includes vegetation base layer).

4. **Kenai Peninsula Region Spruce Beetle Activity 1998 Aerial Detection Survey,** 8 1/2 x 11 in. format (incl. vegetation base).

5. **Copper River Region Spruce Beetle Activity 1993-1998 Aerial Detection Survey,** 8 1/2 x 11 in. format, depicting sequential year-by-year damage (includes base showing extent of forest landscape).

6. **Southeast Alaska Spruce Needle Aphid 1998 Aerial Detection Survey,** 8 1/2 x 11 in. format, depicting aphid activity from aerial detection surveys in Southeast Alaska (includes additional inset map of major activity area).

7. **Southeast Alaska Cedar Decline 1998 Aerial Detection Surveys,** 8 1/2 x 11 in. format, depicting cumulative Alaska yellow-cedar decline over several years (color with shaded relief background)

[Map data for maps 1-6 provided by USFS/S&PF and AKDNR, Anchorage; map data for #7 provided by USFS/S&PF, Juneau]

Map and GIS Products Available Upon Request:

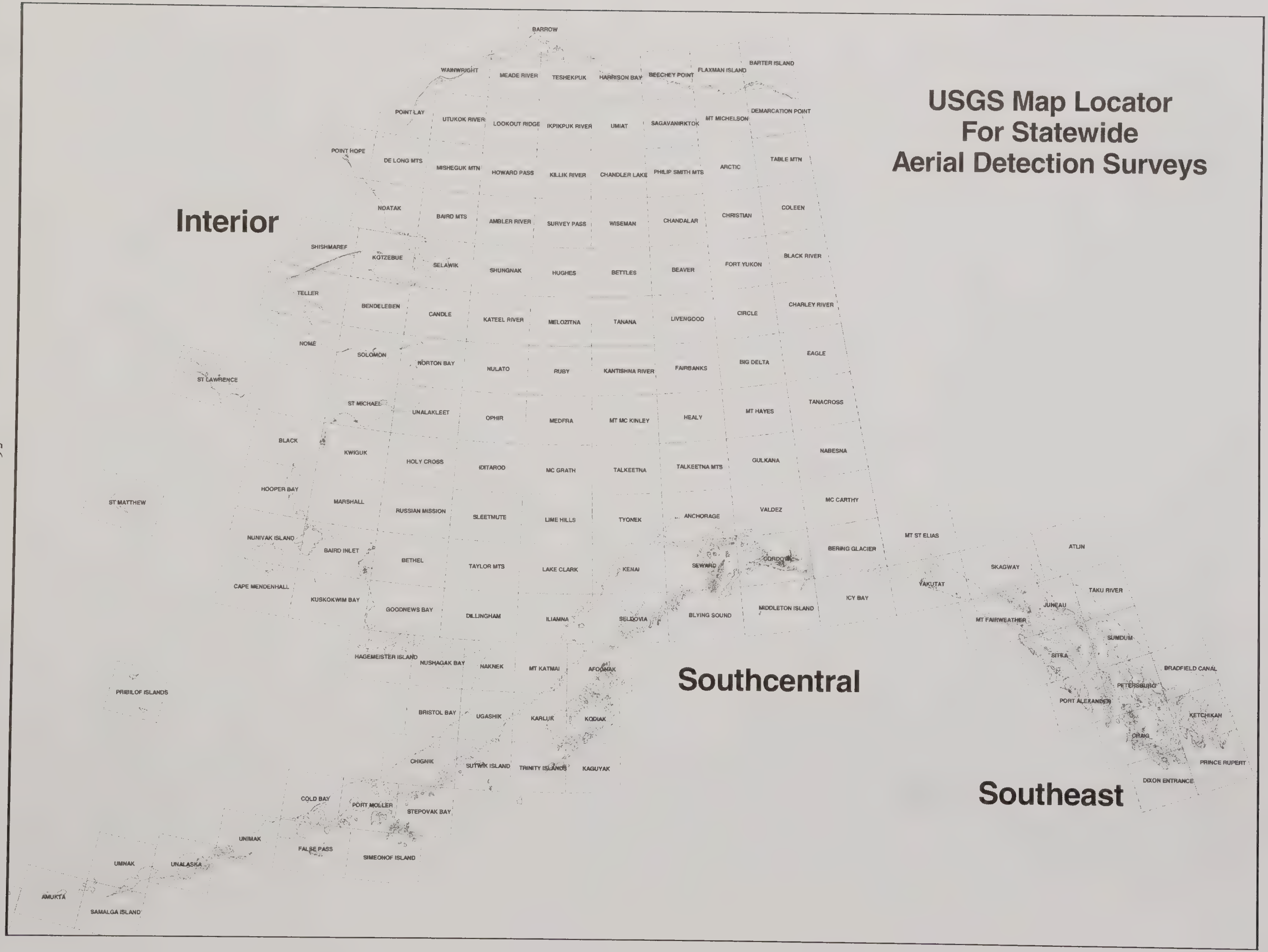
1. Individual GIS quadrangle maps for 1998 surveys on 11" x 17" format (request individual map(s)); maps will be second generation copies from master proof set (SEE USGS MAP LOCATOR ON THE NEXT PAGE) [FOR SPECIFIC AREA OF INTEREST].

2. Digital file information in a miniature quad format showing individual pest damage, major waterways and USGS place names (appropriate data disk must be provided by user).

3. Digital data file of 1998 forest damage coverage in Arc Info (ESRI, Inc.) format —requires a specific written or electronic request if provided through AKDNR/DOF (nominal fee may be required).

4. Cumulative forest damage or specific-purpose damage maps prepared from AK/DOF geographic information system database (specific written or electronic request required; fee may be assessed depending on specific project(s) or map products needed).

5. Forest Insect & Disease Conditions in Alaska CD-ROM v. 1.0 (includes most of digital forest damage coverages in the AKDNR/DOF database in viewable formats and a copy of the 1997 Alaska Forest Insect & Disease Conditions Report in .pdf format; a fee may be assessed depending on availability of copies and amount of data required for the project).


USGS Map Locator
For Statewide
Aerial Detection Surveys
Interior
Southcentral
Southeast
BARROW
WAINWRIGHT
MEADE RIVER
TESHEKPUK
HARRISON BAY
BEECHEY POINT
FLAXMAN ISLAND
BARTER ISLAND
POINT LAY
UTUKOK RIVER
LOOKOUT RIDGE
IKPIKPUK RIVER
UMIAT
SAGAVANIRKTOK
MT MICHELSON
DEMARCATION POINT
POINT HOPE
DE LONG MTS
MISHEGUK MTN
HOWARD PASS
KILLIK RIVER
CHANDLER LAKE
PHILIP SMITH MTS
ARCTIC
TABLE MTN
NOATAK
BAIRD MTS
AMBLER RIVER
SURVEY PASS
WISEMAN
CHANDALAR
CHRISTIAN
COLEEN
SHISHMAREF
KOTZEBUE
SELAWIK
SHUNGNAK
HUGHES
BETTLES
BEAVER
FORT YUKON
BLACK RIVER
TELLER
BENDELEBEN
CANDLE
KATEEL RIVER
MELOZITNA
TANANA
LIVENGOOD
CIRCLE
CHARLEY RIVER
NOME
SOLOMON
NORTON BAY
NULATO
RUBY
KANTISHNA RIVER
FAIRBANKS
BIG DELTA
EAGLE
ST LAWRENCE
ST MICHAEL
UNALAKLEET
OPHIR
MEDFRA
MT MC KINLEY
HEALY
MT HAYES
TANACROSS
BLACK
KWIGUK
HOLY CROSS
IDITAROD
MC GRATH
TALKEETNA
TALKEETNA MTS
GULKANA
NABESNA
HOOPER BAY
MARSHALL
RUSSIAN MISSION
SLEETMUTE
LIME HILLS
TYONEK
ANCHORAGE
VALDEZ
MC CARTHY
ST MATTHEW
NUNIVAK ISLAND
BAIRD INLET
BETHEL
TAYLOR MTS
LAKE CLARK
KENAI
SEWARD
CORDOVA
BERING GLACIER
MT ST ELIAS
CAPE MENDENHALL
KUSKOKWIM BAY
GOODNEWS BAY
DILLINGHAM
ILIAMNA
SELDOVIA
BLYING SOUND
MIDDLETON ISLAND
ICY BAY
YAKUTAT
SKAGWAY
ATLIN
MT FAIRWEATHER
JUNEAU
TAKU RIVER
SUMDUM
SITKA
HAGEMEISTER ISLAND
NUSHAGAK BAY
NAKNEK
MT KATMAI
AFOGNAK
PRIBILOF ISLANDS
BRISTOL BAY
UGASHIK
KARLUK
KODIAK
BRADFIELD CANAL
PETERSBURG
PORT ALEXANDER
KETCHIKAN
CRAIG
CHIGNIK
SUTWIK ISLAND
TRINITY ISLANDS
KAGUYAK
PRINCE RUPERT
DIXON ENTRANCE
COLD BAY
PORT MOLLER
STEPOVAK BAY
UNIMAK
FALSE PASS
SIMEONOF ISLAND
UMNAK
UNALASKA
AMUKTA
SAMALGA ISLAND

Quadrangle Areas Flown During 1998 Statewide Aerial Surveys:

*Quads with no insect damage for 1998 is marked with an asterisk.

South-central Alaska
Anchorage
Blying Sound
Gulkana
Kenai
Kodiak
McCarthy
Nabesna
Seldovia
Seward
Talkeetna
Talkeetna Mts.
Tyonek
Valdez

Interior Alaska
Beaver
Bettles*
Bethel*
Big Delta
Chandalar
Christian
Coleen
Dillingham*
Fairbanks
Fort Yukon
Healy
Holy Cross*
Hughes*
Iliamna
Kantishna River
Lake Clark
Lime Hills*
Livengood
McGrath
Medfra
Melozitna
Mt. Hayes
Mt. McKinley
Nulato
Ophir*
Ruby
Russian Mission*
Sleetmute
Survey Pass*
Tanacross
Tanana
Unalakleet
Wiseman*

Southeast Alaska
Bradfield Canal
Craig
Dixon Entrance
Juneau
Ketchikan
Mt. Fairweather
Petersburg
Port Alexander
Sitka
Skagway
Sumdum*
Taku River
Yakutat

Tree damage codes used in 1989-1998 aerial surveys and GIS map products.

* The codes used for 1998 aerial surveys and GIS maps are marked with an asterisk.

ALB	Aspen leaf blight
ALR*	Alder leafroller*
ASD*	Aspen defoliation*
ASF*	Alder sawfly*
BAP	Birch aphid
BHB	Black-headed budworm
BHS	BHB/HSF
BID*	Birch defoliation*
BLR*	Birch leaf roller*
BSB	BHB/SPB
CDL	Cedar decline
CLB*	Cottonwood leaf beetle*
CLM	Cottonwood leaf miner
COD*	Conifer defoliation*
CTB	Conifer top breakage
CWD*	Cottonwood defoliation*
CWW	CWD and WID
FIR*	Fire damage*
FLO*	Flooding/high-water damage*
HCK	Hemlock canker
HLO	Hemlock looper
HSF*	Hemlock sawfly*
HTB	Hardwood top breakage
HWD	Hardwood defoliation
IPB*	IPS and SPB*
IPS*	*Ips* engraver beetle*
LAB	Larch beetle
LAS*	Larch sawfly*
LAT*	Large aspen tortrix*
OUT*	Out (island of no damage)*
POD*	Porcupine damage*
SBM	Spruce/Larch budmoth
SBR*	Spruce broom rust*
SBW*	Spruce budworm*
SLD*	Landslide*
SMB*	Spear-marked black moth*
SNA*	Spruce needle aphid*
SNR*	Spruce needle rust*
SPA	Spruce aphid
SPBL*	Spruce beetle ("light" damage)*
SPBM*	Spruce beetle ("moderate" damage)*
SPBH*	Spruce beetle ("heavy" damage)*
SPC	SPB and CLB
WID*	Willow defoliation*
WIR*	Willow Rust*
WNT	Winter damage
WTH*	Windthrow/Blowdown*

Note: For all insect activity, the 4th character (L, M, or H) denotes intensity.

L = 1%-10% of the area affected.
M = 11%-30% of the area affected.
H = over 30% of the area

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